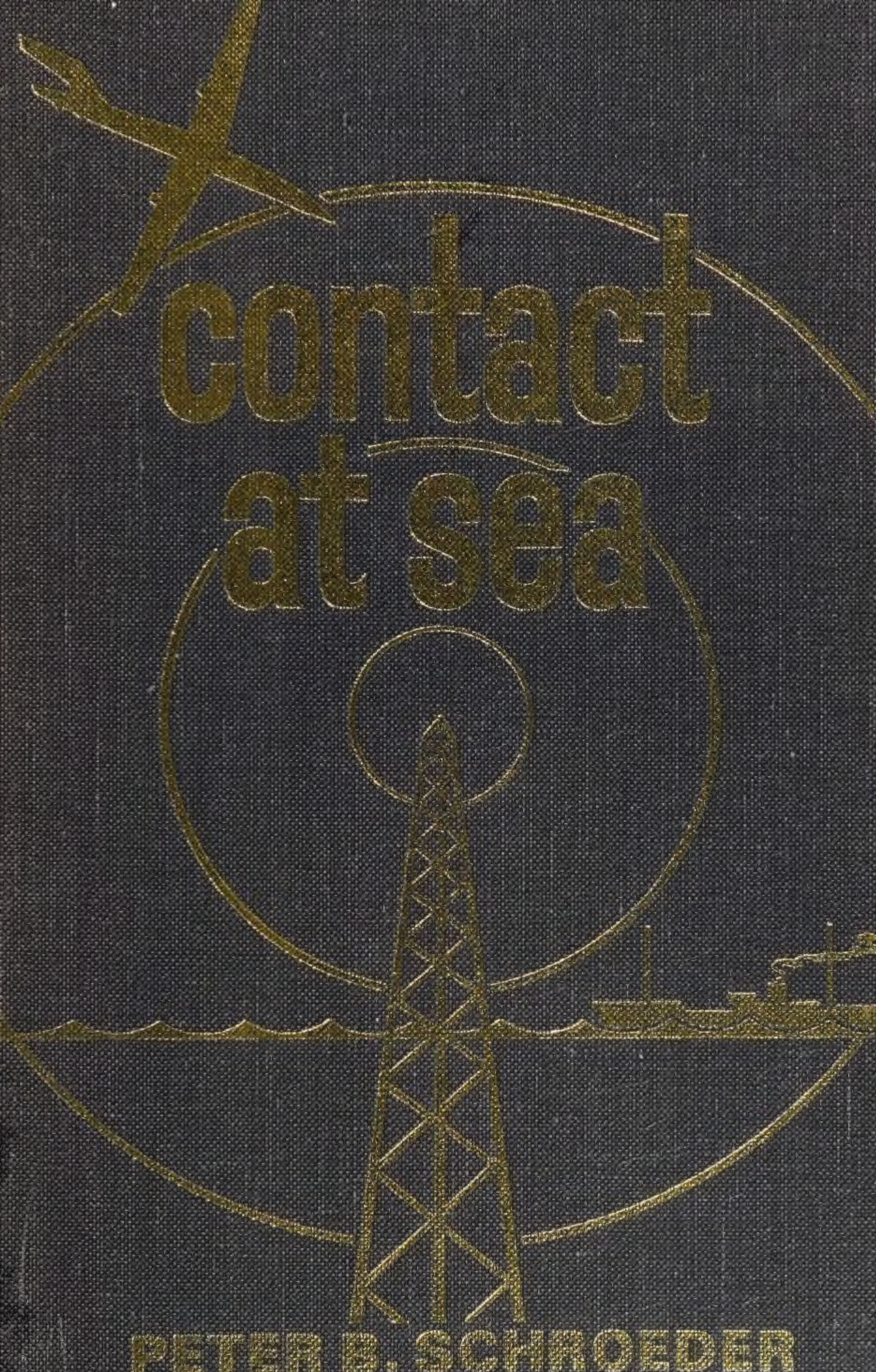
contact at sea



PETER B. SCHROEDER

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CONTACT AT SEA

A History of Maritime Radio Communications

by
PETER B. SCHROEDER

with Introduction by
ROBERT GREENHALGH ALBION

THE GREGG PRESS RIDGEWOOD, N. J.

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CONTACT AT SEA

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INTRODUCTION

From the time Peter Schroeder first mentioned to me his intention to undertake a history of maritime radio communications, I have followed the project with keen interest. Now the finished product goes well beyond my fondest imagination, for it is a clear, well-told and important story. For the first time it covers the subject from all angles and fills a major gap in radio history.

For years I had thought much and written a little about the effects of the "Communication Revolution" with its bringing the world closer together through rapid transmission of information, and its making possible the remote control of distant operations, whether naval, military, colonial, diplomatic, or commercial. I had been particularly impressed by its striking effect in the naval field. In the earlier days, once a ship was off soundings, her commanding officer was pretty much on his own, quite out of touch with what might be developing ashore. In 1812, for instance, HMS *Belvidera* was proceeding up our coast, quite unaware that a state of war existed until she was pursued by an American squadron from which she barely escaped. She carried the news of hostilities to Halifax, whence the Admiralty at London eventually learned of it. At the other end of the war, it was the same. The American *President* was captured in January, 1815, by the British Sandy Hook squadron; neither side knew that peace had been determined at Ghent several weeks before.

The new speedy communication raised an unforeseen question concerning the commanding officer's responsibility. One American admiral claimed that "The laying of the cable to Hong Kong spoiled the old China Station; before that, one really was somebody; after that he became merely a damned errand boy at the end of a telegraph wire."

By World War I, with the new "wireless" in general use, ships could "get the word" at once From there on, by the successive stages which Schroeder describes, such contacts increased until decisions made down at the Navy Department in Washington could almost immediately reach vessels scattered around the world As an ordinary historian, it was not difficult for me to examine such effects of rapid communication. But since I had an extremely limited mechanical and technological aptitude, it was beyond me to analyze the development of the instruments which made such contacts possible.

That is where Peter Schroeder comes in, with his unique dual competence as an historian and as a technological authority. Such a combination was long rare. While we were hunting with scant success to find men capable of writing up the Navy's scientific and technological programs for Naval History during World War II, some one aptly paraphrased Macaulay's comment on the officers of England's Restoration navy: "There are historians and there are scientists, but the historians are not scientists and the scientists are not historians."

Schroeder has maintained his interest and activity in both fields, side by side, down through the years He went through the steps essential to becoming a conventional historian, with a Ph.D. from Clark on top of an A.B. from Yale. He is a specialist in the history of East Asia; his lectures in that and in other fields have made him a favorite history professor at the University of Connecticut He is now at work on a study of the changes China underwent early in this century.

But, along with that, there was the other half of his interest. It happened that he and the age of wireless-radio came into being almost simultaneously at the beginning of this century By the age of ten, in 1912, he had began a half-century of activity as a "ham" radio operator, a role which involved keeping track of all the new technical developments in the field Even today he has his own amateur station WIPNY in his home near Storrs, keeping in touch with developments on a wide range of stations. His connection with radio communication developed still further during World War II, when he served as a naval officer in anti-aircraft warfare. It would be hard to find a better background for such a work as this.

Although he was born in Iowa and lived in South Dakota, about as far as one can get from salt water in this country, Schroeder soon appreciated the particular maritime significance of radio communication at sea. He has chosen to limit himself principally to the impact on merchant shipping, especially to the "safety at sea" aspect In the days before instant communication, the toll of ships that "went missing"

was grim—time after time the Lutine bell at Lloyds would ring out the news that nothing had been heard from an overdue ship. Two of the earliest crack transatlantic liners were in that category. The British *President* was never heard from; her passenger list included a prominent Irish actor, the first Tyrone Power. A few years later, the Collins liner *Pacific* was last seen speeding into a North Atlantic icefield.

As Schroeder brings out clearly, this was an area in which the new "wireless" developments were of prime importance. A preview of this came with the summoning of assistance at the sinking of the liner *Republic* in 1909. The full significance of the new maritime communication, however, came three years later when the superlative new liner *Titanic* ripped out her bottom on an iceberg. One ship, summoned by wireless, rescued some of the passengers, but another, close at hand, missed the chance to save every one because her wireless operator had just turned in for the night. That tragic event accelerated the spread of shipboard wireless because of its dramatic worldwide demonstration of its value in safety at sea. From that time on, the new communication devices have been utilized until, at present, the United States Coast Guard computer system can get the word to the vessels closest at hand not only for rescue work but even, if properly equipped, for ministering to a seaman with acute appendicitis.

There is no point here in further anticipating Peter Schroeder's splendid story. He begins with Marconi's hoped-for monopoly; he tells of the technical developments in which the "spark" gave way to the "tube;" and he gives a play-by-play account of the continuing efforts for international cooperation. This is the first time that any one has brought together within two covers that complete story, competent in its coverage and interesting in its narration.

Robert Greenhalgh Albion

PREFACE

By bringing together the most significant information currently available on maritime communications, I hope to have filled a gap in the literature of radio. Since my attempt at synthesis has by no means exhausted the subject, it may lend encouragement to a later definitive work.

Unavoidably the terminology of radio communications appears in every chapter. Its use, however, should neither irk the engineer nor affright the layman curious about an intriguing subject. Gigacycles and their kindred have rarely been fatal, and their occurrence in these pages is transient.

The theme throughout this study is the historical development of maritime radio communications, especially in its application to the safety of life at sea. For the scope of United States life-saving operations—global in this as in other fields of endeavor—derives its effectiveness from a complex and highly sophisticated communications system. Contact at sea, once limited to the hail of one vessel passing another, may now in protected areas invoke the entire comprehensive process of search and rescue. In the air or on the sea a distress call will bring to focus whatever resources the emergency demands.

Such advances, arrived at with comparatively miraculous speed, are the fusion of technical genius, international agreement, and skilled working units. To the United States for its major contributions to each of these, and especially to the Coast Guard and its counterparts in other areas of the world for their routine achievements, I have given deserved emphasis.

The economic aspects of contact at sea, a separate study, have barely been touched upon. It remains for some one else to do for the

nineteen sixties what Herring and Gross did for the thirties.

For the preparation of this work I am indebted to many persons. Some shared their specialized knowledge in the treatment of specific areas. Others drew on long experience in the field to throw light into dark corners. Still others called to my attention significant material that would otherwise have escaped my notice.

Mr. Carl Taylor, a former Marconi engineer living at Wellfleet, Cape Cod, courteously shared his extensive first-hand knowledge of early wireless (It should not be assumed, however, that he concurs in my assessment of early Marconi policies). Mr. James Wilson of Orleans, Cape Cod, generously made available his experience as radio operator at the French cable station at Orleans, at sea, and at the old station WCC at South Wellfleet. Mr. Edison Lohr, historian of the National Park Service on Cape Cod, drew freely on his special knowledge of this early Marconi station, while Mr. Jean R. Lorraine, manager of the current WCC at Chatham, illumined some of the problems confronting a coastal station in the maritime service. In addition, members of the Old Old Timers' Radio Club, many of whom, like Irving Vermilya, had duty on land and sea in the days of wireless, patiently answered by amateur radio the many questions I posed at the Club's weekly sessions.

Cdr. Charles Dorian, USCG, stationed at Coast Guard headquarters in New York, helpfully made available materials without which certain portions of this study could not have been written. LCDR. Ted L. Gannaway, Communications Officer on the Staff at the Coast Guard Academy, New London, was generous with his time and knowledge, calling to my attention several invaluable sources. Mr. Robert Dixon, Jr., Assistant Librarian at the Coast Guard Academy, helped me greatly by gathering essential material.

I am also indebted to Mr. Francis Colt de Wolf, formerly Chief, Telecommunications Division, Department of State, whose courtesy was unfailing and whose knowledge in this field is profound, to Mr. A.L. Budlong, now retired, who, as Secretary and General Manager of the American Radio Relay League, contributed helpful advice and counsel at several points in this study; to Mr. John Huntoon, present Secretary and General Manager of the American Radio Relay League, whose patient and penetrating responses to my many inquiries were of the greatest values.

Many of the photographs of early wireless installations were contributed by personal friends: Charles and Emily Ellsworth of Hancock, Maine, and Ed Raser of Trenton, New Jersey. For this cordial co-

operation I am happy to express my appreciation.

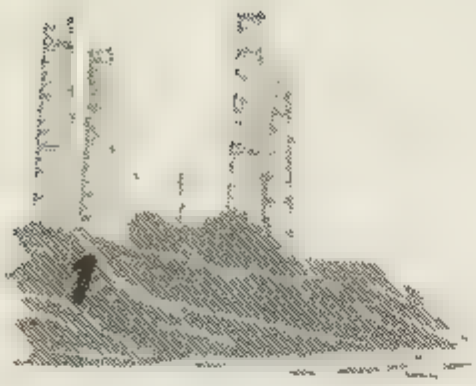
To Robert G. Albion, Professor Emeritus of Oceanic History at Harvard, I owe a special debt for encouragement in inaugurating this study and in pursuing it to completion.

My thanks are also due to the staff of the Wilbur Cross Library at the University of Connecticut, where for the most part, this work was prepared. They were most helpful, painstaking, and patient.

Finally, I am indebted especially to my wife, Violet Taylor Schroeder, whose knowledge of United States Government documents has uncovered numerous sources, and whose perceptive editorial pencil has been wielded with skill and affection.

Peter B. Schroeder

Storrs, Connecticut
July 4, 1964



Chapter 1 In the Beginning

Before Wireless

FROM THE UNRECORDED day when primitive man first pushed away from shore on his hollow log or in his dugout canoe, to the end of the nineteenth century, there was little significant advance in maritime communications. All contacts, ship-to-ship and shore-to-shore, were limited to visual or aural devices. Improvements in ship design and construction, along with better navigational instruments (the magnetic compass, astrolabe, chronometer), made long ocean voyages possible; but individual ships, until they made port, were usually cut off from each other and from the outside world.

As early as 200 B.C. the Greeks had developed a semaphore system for ship-to-ship and ship-to-shore signaling,[1] but it was not until the seventeenth century that signal flags were used, first by the British Navy.[2] The flag signal system has many times since been expanded and improved and is now internationally recognized as a widely used and essential system for visual distances. The seventeenth century also saw the adaptation of rockets[3] to shipboard use, which, in more sophisticated form, are still employed today as a distress signal.[4] Useful as these devices were and still are, their effectiveness has necessarily been limited to optical distances and good weather. It remained for the invention of wireless to effect the first real breakthrough in maritime communications since man took to the sea in ships.

Forerunners of Marconi

While the name *Marconi* is inseparably associated with the earliest workable system of wireless communication[4a], it should be remembered, as Marconi himself concedes, that he built on the foundations laid by earlier pioneers in the field. Maxwell, the Scottish physicist, published a significant treatise in 1873 in which he concluded, on a

mathematical basis, that electricity and magnetic energy travel in transverse waves (at the speed of light)—a fundamental postulate in understanding radio waves and their behavior.

Hertz, acknowledging his debt to Faraday and Maxwell, saw his own work as confirmation of the latter's thesis and was the first to discover and demonstrate the propagation of electromagnetic waves through space—later known as "Hertzian waves." This he demonstrated by the use of a high-frequency oscillator, the radiations of which he was able to pick up at a distance of ten meters on a receiver—a small loop of wire with a gap across which arced a minute spark induced by the oscillator -in effect, an elementary forerunner of the first wireless transmitter and receiver. In a paper published in 1888 he described his experiments with their results—a paper that subsequently caught the eye and captured the imagination of a young man by the name of Guglielmo Marconi. Not understood at the time, nor in fact for a half century later, was the significance of Hertz's conducting many of his experiments at microwave frequencies (30 cm). In fact he himself saw his discoveries as having no practical application in telegraphy since, as he remarked, such application would require a mirror of continental dimensions. Neither he nor any one else yet knew of the ionosphere with its reflecting properties,[5] and it was not until 1902 that Oliver Heaviside and Arthur E. Kennelly, co-discoverers of the ionosphere as a reflector of radio waves, published their theories accounting for wireless transmissions beyond the horizon.[6]

In 1891 a French scientist, Edouard Branly, invented and demonstrated an ingenious device—a glass tube containing metal filings that cohered under the impulse of electromagnetic waves, and decohered when a small tapper jarred the tube. Known as a coherer, it became the detector used by Marconi and others and so constituted a long step toward a workable system of wireless communication.[7] By acting as a rectifier, the coherer converted the alternating current of the received radio frequency impulses to direct current that could register as dots and dashes in the headphones of the operator. The Branly coherer was soon displaced by more efficient instruments such as the magnetic, electrolytic, and crystal detectors, and these, in turn, were rendered obsolete by the vacuum tube. The latter, more recently, has given way in many applications to the versatile transistor with its small size, long life, and low power requirements.

It remained for John Ambrose Fleming, colleague of Marconi and scientific adviser to the Marconi Wireless Telegraph Company, to develop the vacuum tube as a detector in receiving circuits. In 1883 Thomas Edison had noted that the interior of the bulb of his in-

candescent lamp had blackened by bombardment from the hot filament (the so-called "Edison Effect") and had ascertained that this phenomenon was accompanied by a flow of current—in one direction only. Pursuing Edison's discovery further, Fleming placed a metal cylinder around the filament and discovered that he had a rectifying tube. The initial application of his "thermionic valve" was in the rectifying of commercial current, but it gradually came into use as a component in wireless receivers.[8] Here again it is necessary to glance ahead to note the successor to Fleming's valve, for just when the Marconi Company had begun to incorporate it in its receivers, a new development rendered it obsolete. For in 1906 Dr. Lee De Forest revolutionized the vacuum tube by adding a third element, the grid, which not only made the device a vastly superior detector but an amplifier as well, opening the way to the development of the radiotelephone. This brilliant contribution has been termed one of the twenty great all-time inventions.[9]

Marconi: No Competition

Marconi had first read about the experiments of Hertz in 1894, and he was immediately captivated by the communication possibilities that he envisaged. Undeterred by the fact that he was about to breach a new frontier without guideposts, he gathered together what equipment he could and set to work. On a cut-and-try basis he improvised circuitry and antennas as he went along, achieving in 1896 a transmission of about 100 yards.[10] Taking out his first British patent in that year, he demonstrated a flair for business acumen that was to characterize his subsequent career. In 1897, a 7½-mile wireless circuit, the first of its kind, was set up between two lighthouses off the coast of Northern Ireland.[11] The following year Marconi extended his transmission distance to 18 miles and shortly thereafter to 196 miles. His invention of a new tuning technique in 1900 (patented the same year in Britain) constituted a significant advance in the newly emerging art. The climax of his early experiments came in 1901 when the Atlantic, for the first time, was spanned by wireless.

In preparation for this memorable attempt Marconi, aided by Fleming, erected his transmitting station at Poldhu in Cornwall, England. His receiving station, using a kite-supported antenna, was at St. Johns, Newfoundland—the easternmost point of land under British control in North America. The reception of the letter "S" marked the success of the experiment, and was triumphantly confirmed by cable dispatch.

Elbowed out of Newfoundland by unfriendly British cable interests, Marconi then set up his station at Glace Bay, Cape Breton Island, Nova Scotia. Some two hundred miles to the west of St. Johns, Glace Bay also overlooked the waters of the Atlantic. Here occurred the first interchange of messages across the Atlantic on December 17, 1902.

A month later, on January 19, 1903, the Marconi station (original call letters were CC; later MCC; still later, WCC) at South Wellfleet on Cape Cod opened with an exchange of messages between President Theodore Roosevelt and King Edward VII.[12]

Further application of Marconi's developments—now to maritime communication—was the equipping of ships in regular service with wireless: initially the American steamship *St Paul* in 1899 and the German steamship *Kaiser Wilhelm der Grosse* in 1900.[13] Presumably the first wireless distress call at sea was sent out March 3, 1899, by the East Goodwin Lightship near Dover, England, when it was rammed by the freighter *R F. Matthews*.[14] The first distress call by a ship underway at sea was sent out January 23, 1909, by the *Republic*, rammed in an early morning fog by the *Florida* some twenty-six miles southwest of Nantucket. Intercepted by the Marconi shore station MCS at Siasconset, the *Republic's* CQD was relayed by wireless to other ships in the area: the *Baltic*, *Furnessia*, *Lucania*, *New York*, and *La Lorraine*. Woods Hole was notified via submarine cable so that a cutter could be dispatched. Because of dense fog and heavy seas, the *Baltic*, inbound, though only ten miles away, took twelve hours to locate the sinking *Republic*. Meanwhile the passengers from the *Republic* had been transferred to the *Florida* for greater security, and by the time the *Baltic* finally reached the scene it was decided to take both contingents of passengers from the *Florida*. With survivors from both ships on board, the *Baltic* then proceeded to New York. The *Florida* made port successfully, but the *Republic* sank while under tow off Martha's Vineyard.[15]

It is evident at this point that Marconi's genius lay in the ability, determination, and imagination with which he took basic theories and experiments of earlier pioneers out of the laboratory and from them developed a workable system of communications. In addition he had the foresight to draw to himself men like Fleming and others who often made major contributions to the art.

His business shrewdness was as sharp as his developmental instinct, and he was quick to see the possibilities of commercial exploitation in the use of the ship and shore stations that he set up. As early as the Berlin Conference of 1903 it had been pointed out that Marconi had personally directed the construction of forty-eight land and

coastal stations in the United States, Britain, Canada, and other countries; that he had stations on thirty-two ships of the North German Lloyd Line, the Hamburg-American Line, the French Line, the Cunard Line, and the American Line; that his stations had been installed on a number of American, British, French, and Italian warships.[16]

Marconi quickly sensed that the production of equipment alone would not insure his continued preeminence in the field of wireless. Consequently, within a year of securing his first patent in Britain, he organized the Wireless Telegraph and Signal Company, Ltd. (1897) to take over Marconi patents. In 1900 the name was changed to the Marconi Wireless Telegraph Company, Ltd., more commonly called British Marconi, or the "Company." The latter not only produced wireless apparatus but expanded as well into the operations field. It was its policy to organize its own wireless service—installing its equipment on lease in ship and shore stations, providing operators trained in the "Marconi tradition," and setting up shore stations on the major trade routes of the world. In this way, as Hancock says, "With uniform control, confusion was prevented and the service brought to the highest pitch of usefulness."[17] The Company's efforts were wholly rewarding: it acquired most of the patent rights registered in Great Britain as well as exclusive rights to patents registered in many other countries.[18]

Subsidiaries were quickly organized. For example, the first radio company organized in America was the Marconi Wireless and Telegraph Company of America, incorporated in New Jersey in 1899. Moreover, American Marconi had the exclusive rights of the British Company for the construction and use of land wireless stations in the United States and of ship stations of American registry. In addition, the Marconi International Maritime Communications Company, Ltd., was organized in 1900 by the parent company in Britain to oversee a worldwide maritime wireless service, and the Marconi Wireless Telegraph Company of Canada was set up in 1903.[19] Illustrative of the Company's policy to install its equipment aboard ship and to supply the operators is the fact that in June 1913, some 686 ships of all registries were so equipped,[20] and by the end of 1915 over 400 ships of the American Merchant Marine also fell in this category.[21]

While British-controlled American Marconi was showing these spectacular gains, several American companies were making their bid in this new and rapidly developing field. The De Forest Wireless Telegraph Company of America was organized in 1903 with stations on the Atlantic and Gulf Coasts and on the Great Lakes. Its title of

incorporation was changed in 1905 to the American De Forest Wireless Telegraph Company, which, in 1907, was taken over by the United Wireless Telegraph Company The latter expanded its operations to the Pacific Coast, and by 1912 had equipped some 250 American vessels with wireless apparatus. Others were the Federal Telegraph Company of California, incorporated in 1911, and the Tropical Radio Telegraph Company (one of the first users of the word *radio* instead of *wireless*), in 1913 as a United Fruit subsidiary.[22]

Regarding itself as a pioneer in the field of wireless communication, British Marconi saw no valid reason why it should be restrained in enjoying the fruits of its enterprise. Ship-to-shore communications loomed as a rich field for exploitation, and the Company's ground-floor position in Britain—the leading maritime power of the world - made the prospects highly attractive. The contract between British Lloyds and Marconi International Marine Communications not only provided for the installation of Marconi equipment and the furnishing of operators, but contained as well a proviso that no communications would be carried on with stations (ship or shore) other than those which Marconi controlled. This non-intercourse policy was to apply to subsidiaries as well, and on a worldwide basis.[23]

Hancock's optimistic observation that "With uniform control, confusion was prevented . . ." is, unfortunately, not borne out by the record. The Marconi policy of non-intercourse and the jamming of non-Marconi transmissions led to prodigal anarchy on the maritime wave lengths (frequencies), and the ensuing uproar always carried with it the possibility of endangering the safety of life at sea since a distress call could not be heard through such commotion Wireless found itself in the state of nature described by Thomas Hobbes as ". poor, nasty, brutish, and short." On this lamentable situation Harlow writes:

> The British Marconi Company, considering itself. . .entitled to a monopoly, and fancying that it could, by a system of non-intercourse and interference, drive competitors out of business, had placed British operators who would obey orders in all its ships and stations. . . These men had strict orders to hold no converse with and receive no messages save the distress call from operators employed by other countries. An absurd and ugly situation thus developed, for other companies took the cue and retaliated in kind.
>
> Marconi operators would give no news of dangerous derelicts, no storm warnings to alien vessels, if they

> heard another company sending, they would often 'lay a book on the key' and blast out the other fellow's signals. . . . Marconi operators were even ordered to work against their own vessels; to deliver to the Captain no messages other than Marconi unless he specifically demanded those from a certain other vessel or correspondent.[24]

Examples are numerous, but two will suffice. A group of United States government officials and Congressmen on a trip to the Canal Zone were cut off from Washington for days because the nearest shore stations were competitors of their ship's station.[25] On another occasion as Prince Henry, brother of the German Emperor, was returning home from a visit to President Roosevelt and neared European shores, he attempted to send a message of appreciation to his host for the hospitality tendered him. This he was unable to do because British land stations refused to accept the message for relay to the United States. The German vessel on which the Prince was traveling was equipped with Telefunken apparatus, and the Marconi policy of non-intercourse held firm.[26]

In this connection Vyvyan relates a revealing incident that occurred following Marconi's transatlantic experiments when Marconi and the German Emperor were both guests of the Italian government. Discussing wireless with the inventor, the Emperor remarked that while he had no personal animosity toward him, he did object to his Company's policies; to which Marconi's reply was that ". . . the policy of my company is dictated by myself."[27]

While Marconi sought monopoly in the new field of wireless communication by shrewd, determined, and at times ruthless methods, he had no monopoly on tactics of this kind. The age of industrial expansion affords many examples of greed, cunning, and cutthroat competition—of pushing into bankruptcy a competitor who would not sell out or surrender. The industrial barons of our own Gilded Age offer trenchant examples of this sort, and it is possible that Marconi himself would have winced at the famous remark of Commodore Vanderbilt, "The public be damned." The phenomenal advances in science and industry during the past century have generally outrun the means of social control in that developments have taken place much more rapidly than regulatory devices framed in terms of the public interest. One of the unusual aspects of the wireless story is the relative speed with which national and international legislation was brought to bear to resolve what had become an intolerable situation.

Chapter 2 The Search for Remedies by International and National Action to World War II

Aspects of the Problem

BEFORE RECOUNTING the attempts to bring order out of chaos, it is important to note that at this time wireless was overwhelmingly maritime, for there was no alternative method of communication beyond visual distances Land areas, in varying degrees, were served by telegraph and telephone, and intercontinental regions to an increasing extent by submarine cable. A few land wireless circuits were in use, but most land stations were operating in the maritime service and were located on or close to the shore, preferably on a cliff overlooking the ocean as at Poldhu, England, and South Wellfleet, Massachusetts. This was seen as necessary in view of the limited range of early wireless, with the result that the Marconi and other companies placed their land stations at strategic points as close as possible to the major shipping routes.[1] It should also be remembered that while a powerful land or shore station in these early days could project its spark signal a thousand or more miles out to sea, ship stations did not have a similar capability The massive equipment necessary for long distance transmission was obviously impractical for shipboard installations, where a battery-powered spark coil (some generating a six to eight-inch spark) was commonly used. This type of equipment gave ships a transmission range of approximately one hundred miles, enabling them to communicate with "appropriate" ship- and shore stations within that radius. At the same time they could copy transmissions of shore stations at a distance of a thousand miles or more depending on conditions (static, interference, etc.) and the power employed by the shore station.[2]

Wireless in the first decade and a half of the twentieth century labored under the limitations of an art that was still in its infancy, while it was at the same time denied the full potential of its capa-

bilities by prevailing operating practices and policies of a restrictive nature, some of which have already been noted. The confusion on the "air waves" was in part due to technological underdevelopment, but even more to disturbances that were man-made and directed. Regulations, spelled out in detail in later telecommunication agreements, were virtually non-existent. A ship's operator tended to be a law unto himself, using the ship's wireless equipment to suit his own varied whims. Gossip between operators who were old friends was common and frequently interfered seriously with traffic handling by others within range. Operators on liners regarded operators on freighters with scorn and treated them accordingly. Precedence and priorities in message handling were virtually unknown, and it was not uncommon to have the air filled with choice obscenities.[3] This unlovely structure was crowned by the ban on intercommunication, earlier described, one of the major problems toward which the maritime wireless community of the early 1900's directed its concern and attention.

The urgency of the problem of obligatory intercommunication[4] requires little reiteration. While Marconi was the first on the scene, and for years produced the best wireless equipment available, the fact remains that his rigid policy of non-intercourse with other systems became increasingly intolerable in the eyes of most maritime nations because of the threat it posed to safety of life at sea. It was not until 1912—shocked into action by the *Titanic* disaster—that Marconi and the countries supporting his policy (Britain and Italy particularly) finally yielded on this point. It is no coincidence that every international radio treaty since 1912, and much national legislation as well, has carried a clause on obligatory intercommunication.

Closely related to the above, and still a severe problem at times today, was avoiding needless interference with other stations. The competing of too many broad-band spark stations for the same wave-length often resulted in the frustration of all in attempting to clear their traffic. Various attempts to deal with this difficult problem over the last sixty years will be dealt with in the course of this study.

Equally important was the third problem—that of determining a generally accepted and rational pattern of frequency allocations. It was essential, in the interest of establishing effective communications, that the different categories of wireless service know where in the wireless spectrum they could find their counterparts. Ranging at random over the wireless spectrum from 300 to 10,000 meters could be interesting but singularly unproductive. It was particularly urgent that a common wave-length be agreed upon for distress calls—a step that was not taken until 1912.

Significant also was the problem of operator qualifications. An inept or inadequately trained operator could make a shambles of any given wave-length. It was essential that he be able to send and receive at an adquate rate of speed and with accuracy; that he be able to adjust his apparatus in an efficient manner; that he follow established procedures and forms for message handling; and that he be a professionally responsible individual, for on his skill might rest the lives of his shipmates. Finally there was the matter of the technical efficiency of the apparatus used in ship or shore stations.[4] To perform its function effectively it had to be designed and constructed according to the highest known standards of the art. It quickly became apparent that transmitter tuning and receiver selectivity would have to be much improved not only to permit more certain communication but to reduce needless interference. This, too, has been a continuing problem down to the present day, carrying with it the pain of added financial outlay stemming from obsolescence in a rapidly changing art.

Successive international conferences and national legislatures have grappled with these considerations since 1903—a series of developments to which this study now turns.

The Berlin Conferences of 1903 and 1906

The nine powers[5] that met in Berlin in 1903 at the invitation of the German government were confronted with a situation of increasing seriousness to countries whose ships were just beginning to use the new medium of wireless communication. The Marconi interests, through favorable contracts and their policy of non-communication with other systems, were attempting to establish a monopoly over a medium that was in large part international in character. Most of the powers at Berlin felt that a continuation of this policy "... would not promote safety of life at sea and would be a tremendous handicap to the orderly growth of the new art."[6] The head of the German delegation, pointing to the restrictive practices of the Marconi Company, urged on the conference the adoption of measures to eliminate interference and to require intercommunication regardless of type of system used.[7] Opposition to this proposal was immediately voiced by both Great Britain and Italy. The delegate from Great Britain argued that its Postmaster General did not possess the power to impose regulations such as those presented, and that Parliament would be reluctant to enact legislation that would "prejudice the rights" of existing companies. The Italian delegate, citing Marconi contracts with his country, made the happy suggestion that the simplest solution to the whole matter lay in adopting universally the system that was most efficient—that,

of course, of Marconi.[8] There was a good deal of relatively fruitless give-and-take of this sort in the conference discussions, but the important fact—of bringing several basic issues out into the open—was well served.

The basic problems of the early wireless world are set forth in the preceding section of this chapter, in connection with which several provisions of the Final Protocol of Berlin are of particular interest. They may be summarized as follows: ship-to-shore traffic to be handled regardless of the system used; technical information to be published by the contracting parties to expedite communications between ship and shore stations; terms of the International Telegraph Convention to apply to wireless messages as long as the latter were not in violation of the Convention; distress calls to have priority; wireless stations to operate in such a way as to avoid interference with other stations; contracting governments to have the right to arrange among themselves for the compulsory observance, by operators within their jurisdiction, of any Convention provisions entered upon.[9] Great Britain and Italy did not sign the Protocol, but made separate declarations: Britain with respect to intercommunication and interference, Italy on intercommunication, the exchange of technical information, and the compelling of operators to observe the Convention terms. Six powers signed the Protocol, but the problem of obligatory intercommunication remained unresolved.[10] The pattern of approach to the rationalizing of international wireless communication had, however, been laid down, and future conferences would proceed from this point.

The second Berlin Conference (1906) had been planned originally to meet in 1904, but the Russo-Japanese War (1904-5) threw the negotiating atmosphere into some disarray. Consequently it was not until thirteen months after the Treaty of Portsmouth had been signed (September 5, 1905) that the meeting could be convoked.

Although the number of ship and shore (coastal) stations had increased since 1903, few countries had adopted regulatory measures. Technical improvements had been made in wireless apparatus, but there was no rush to put them into practice in the absence of mandatory requirements. The air was free to all; and in the areas of maritime traffic congestion, effective communication depended on mutual cooperation and good-will. The latter were frequently lacking, and deliberate interference by operators using different systems was still all too common.[12]

As was to be expected, the delegates of the thirty nations represented addressed themselves primarily to the problem of intercommunication and interference.[13] It was something of a concession when the British

delegation showed a willingness to yield in part on the issue of obligatory ship-to-shore communication provided certain coastal stations were made exempt, and provided also that regulations be adopted to prevent interference with such stations.[14] What really shocked the British delegation, however, was an American proposal that intercommunication be made obligatory not only between ship and shore stations, but between ship stations as well. The head of the British delegation warned that he would not sign any convention containing such a provision, and it was embodied in an additional agreement ultimately signed by twenty-one delegations.[15] Further to protect the Marconi Company, the British delegation proposed that a coastal station accepting messages from a ship using another system be authorized to collect a surtax double that of the prevailing rate. There was little support for this proposal, except from Italy, and it was defeated in committee.[16]

British Marconi had not been idle after noting the trends apparent at the 1903 Conference, and new contracts had been negotiated: (1) with the Admiralty, providing that where Marconi apparatus was used for public correspondence, traffic would be accepted only from other stations similarly equipped. The Company was to be indemnified in the event that the Admiralty should be prevented by legislation from fulfilling the terms of the contract; (2) with the General Post Office, authorizing the Company to collect for seven years a surtax on messages exchanged with non-Marconi stations in case Britain adhered to a convention based on the 1903 Protocol.[17]

The conference did subscribe, on a limited basis, not to the principle of a surtax on messages between different systems, but to the concept that coastal stations that were particularly expensive to construct and operate should be authorized to charge a rate higher than the established maximum.[18] This may be a distinction without a difference, since most of the stations affected would be those controlled by the Company. Among other principles incorporated in the Convention[19] there may be noted the following: signatories were obliged to integrate their coastal stations (wireless) with the international telegraph system so as to ". . .insure a rapid exchange between the coastal stations and the telegraph system." The signatories were also obliged to control their wireless stations so as to avoid interference with other stations; and distress calls from ships were to have absolute priority.[20]

While the fundamental problem of obligatory intercommunication was barely scratched, not solved, there were some substantial gains at Berlin in the direction of bringing order out of the prevailing chaos in maritime wireless. Certain provisions of the Regulations will illustrate

the point. In recognition of the importance of insuring the safety of life at sea, a common distress signal, SOS (...---...) was adopted as a replacement for CDQ previously in use. All stations hearing the call were to cease handling traffic until the emergency had been terminated, and were bound to answer the distress signal.[22] Technical standards of apparatus used were to be kept as high as possible, and ship stations were to be licensed by the government under which they operated. Operators likewise had to be certified as to technical proficiency, knowledge of regulations, and code speed (20 words per minute).[22] In the hope of reducing interference the power of a ship's transmitter was to be limited to one kilowatt; operator practice using the ship's transmitter was forbidden, as was unnecessary testing and the exchange of needless words or signals.[23] Enforcement of these provisions was the responsibility of the individual governments.

Frequencies were specified as 300 and 600 meters for the maritime service, while wave-lengths over 1600 meters were designated for coastal station long-distance communications. Wave lengths between 600 and 1600 meters were set aside for military and naval stations ("services not open to public correspondence"). Each administration was required to forward to the Berne Bureau data on its ship and shore stations, e.g., call letters, wave-lengths, hours of operation, type of system used.[24] Orderly procedures were also prescribed, particularly with respect to ship-to-shore traffic in which the shore station determined the order or priority with which it would receive messages.[25]

The accomplishments of the Berlin Conference of 1906 can be briefly summarized. With respect to the basic problem of obligatory intercommunication, little more than a beginning was made. On the matter of frequency allocations progress was more substantial in terms of what were felt to be the needs of the day, but the allocation of only two frequencies (600 and 300 meters) meant that the hoped-for reduction in interference between stations would in considerable degree be nullified. Prescribing qualifications for operators was an excellent step in the right direction, the effectiveness of which depended on the licensing program of the various administrations. Urging adherence to the highest known technical standards for apparatus was a most praiseworthy exhortation, but a sticky one to enforce because of rapid obsolescence in an art the technology of which was constantly advancing. Finally, it was agreed that there should be a universal distress call for the maritime wireless service—a call that would have priority over all other types of wireless communication. Oddly, the Conference did not specify a particular wave length for the use of this call -a gap that was filled by the next conference in 1912.

The United States Radio Law (Wireless Ship Act) of 1910.

The Radio Law of 1910, in its provisions and its effect on international legislation in the field of maritime wireless, is so significant that it is here quoted in part:

> That from and after the first day of July, nineteen hundred and eleven, it shall be unlawful for any ocean-going steamer of the United States, or any foreign country, carrying passengers and carrying fifty or more persons, including passengers and crew, to leave. . . any port of the United States unless such steamer shall be equipped with an efficient apparatus for radio-communication, in good working order, in charge of a person skilled in the use of such apparatus, which apparatus shall be capable of transmitting and receiving messages over a distance of at least one hundred miles, night or day: *Provided*, That the provisions of this act shall not apply to steamers plying only between ports less than two hundred miles apart.
>
> Sec 2. That for the purpose of this act apparatus for radio-communication shall not be deemed to be efficient unless the company installing it shall contract in writing to exchange, and shall, in fact, exchange, as far as may by physically practicable, to be determined by the master of the vessel, messages with shore or ship stations using other systems of radio-communication.
>
> (Sec. 3 and 4 prescribe penalties for violation of the act, and designate the Secretary of Commerce and Labor as responsible for its execution.)[26]

In requiring radio apparatus on vessels carrying fifty or more persons, the Act went considerably beyond the provisions of the Berlin Convention of 1906 and set a precedent that was to be followed in every subsequent radio convention. The British Wireless Telegraph Act of 1904[26a] was instrumental toward the same end, and similarly expedited the equipping of British ships with Marconi apparatus It contained no clause such as Section 2, previously quoted.

This same section of the Act, with the Berlin Conference of 1906 obviously in mind, met the challenge of intercommunication head-on. Since no ship, of any nationality could leave an American port (if it carried fifty or more persons) unless it met the requirements of Section 2, it naturally gave pause to those nations whose passenger vessels

were Marconi-equipped and who prized the American trade. The interim between the effective date of the Wireless Ship Act of 1910 and the London Radiotelegraph Conference of 1912 gave ample time for reflection on the matter. Meanwhile on April 14, 1912, the *Titanic* disaster provided added tragic urgency toward modernizing international radio regulations.

The Titanic Disaster

At 11:40 p.m. Sunday night, April 14, 1912, an iceberg sliced into the new luxury liner *Titanic,* leaving a fatal 300-foot underwater gash in her hull. Two hours and forty minutes later the "unsinkable" ship went down, bow first, some 900 miles E.N.E. of Cape Race, Newfoundland. Despite ice warnings from five other ships and the steady dropping of sea temperature to 31 degrees, the 66,000-ton vessel had been proceeding at better than 22 knots. At 12:15 Monday morning the distress signal (CQD followed by the new signal, SOS) went out and was heard by numerous ships. Responding with a forced run of 58 miles to the scene, the *Carpathia* picked up from the partially filled lifeboats (there was provision for only 1178 of the 2207 persons on board) the 705 survivors subsequently reported. But the wireless on the *Californian,* ten miles away, was not manned at the time; and although the deck officer saw the *Titanic's* rockets and reported them to the captain, no action was taken. Thus some 1500 persons perished and a magnificent liner went down to her grave.

This disaster rocked the maritime world and precipitated a drastic reappraisal of seagoing practices and regulations. The bulkhead construction of the *Titanic,* advanced for its time, was faulty; there was as yet no international ice patrol; the wireless of the day, primitive by modern standards, was adequate to the crisis, but the station was unattended on the ship best situated to provide speedy succor; there were lifeboats for only half the total number of persons on board the stricken ship, and the crew was untrained in their launching.[27]

Disasters at sea have obviously been a most potent incentive to improve ship structure and stability, to tighten up on navigational procedures in dangerous waters, and to perfect means of communication, ship-to-ship and shore-to-shore—all in the interests of safety of life at sea. It is a melancholy reflection that necessary forward steps in this direction so often have had to be impelled by tragedy[28]—as in many other areas where human life and welfare have been imperilled. On the sea, radio communication[29] has had an indispensable role to play, for there have been no alternative means of summoning aid or of mobilizing rescue forces to assist an endangered vessel. The *Titanic*

loss shocked the maritime world into a realization that the restrictive practices upheld by Britain, Italy, and others in deference to the Marconi interests could well be a contributing factor to disaster at sea. There were no provisions in the Radio Regulations for continuous watch standing on passenger vessels; most ships carried only one operator:, the lone operator on the *Californian* had just turned in (after 16 hours on duty) when the *Titanic* distress call went out; the operator on the *Carpathia* was just securing for the night when he heard the *Titanic's* appeal, and alerted his captain. Except for a few major maritime countries, most did not require radio on their ships. These and related problems were to be considered and acted upon in two successive international conferences, both at London, in 1912 and 1914.

The London Radiotelegraph Conference of 1912

It had been decided at Berlin in 1906 to hold the next radiotelegraph conference at London in 1912, at which time the Convention and Regulations would be reviewed.[30] In the interval between the two meetings the number of radio stations, ship and shore, had increased substantially (to 2752 ship, and to 479 shore)[31]—the increase in the number of stations on ships being due, in large part, to compulsory national legislation; while the rise in the number of shore stations had resulted from the need for more stations to handle the increasing load of ship-to-shore traffic. Radio was still (in 1912) overwhelmingly a maritime service; and while a few dirigibles had been fitted with radio, a fact which was noted at the Conference, no attempt at that time was made to meet the problems of an "aeronautical" service.[32] Work was being pushed on powerful stations by Great Britain, Germany, the United States, and Canada to handle trans-Atlantic correspondence,[33] and with stations of this type in operation a new category, "fixed," would find its way into the registry of the Berne Bureau. Of these, some eighty-one were listed by 1914,[34] most of the fixed stations already in use being military or naval and not open to public correspondence. Consequently, while they were noted in the London Convention, they were made exempt from the regulatory provisions except for those rules relating to interference and distress calls.[35] It was unmistakably clear that the great increase in the number and types of radio stations would impose a severe burden on the regulatory ingenuity of the London and subsequent conferences.

The demon harassing intercommunication was finally exorcized at London when, early in the Conference, Italy, Japan, and Great Britain announced that they were ready to support the article of the Con-

vention prescribing intercommunication irrespective of the system used. To this pledge was added a statement by the Marconi Company that it had ordered all its ship stations to communicate with other ships "regardless of the system adopted by the latter."[36] This complete reversal of policy can be attributed to several factors. One was the shock of the *Titanic's* loss, as indicated in the opening address of the British Postmaster General, who said: "The recent disaster of the '*Titanic*' . . . has shown the necessity for a wider use of radiotelegraphy on the open sea and for the investigation of new methods to make it more effective in its important duty of preventing disasters and assisting in rescue work."[37] The subsequent unequivocal British commitment to obligatory intercommunication, followed by similar action on the part of Italy and Japan, ended a period of harassment that had plagued maritime radio communications for ten years.

Significant also was the fact that the Marconi contracts with British authorities had expired in 1911, thus providing a greater degree of flexibility to Britain's position at the Conference.[38] Finally there was the clear lesson in the American Wireless Ship Act of 1910, with its mandatory radio provisions applying to *all* passenger ships leaving an American port. Confronted with opposition of this kind, which it was powerless to control, the Marconi Company had no alternative but to relinquish its strangling embrace on the field of maritime radio.[39]

Out of considerable discussion on additional frequency allocations it was decided to continue the existing 300 and 600 meter wave lengths for ship and coastal stations, with the latter to be equipped to operate on both frequencies. At the same time the frequency of 600 meters (500 kilocycles) was indicated as the wave length to be used by ship stations. Ships unable to transmit on 600 meters could use 300, but it was required that they be able to receive on 600.[40] It was the 600-meter frequency that was designated as the universal marine distress frequency, in an attempt to set up a uniformity in practice that would enable a distress call to be heard by the largest possible number of stations, both ship and shore. The obvious advantage of this specification was that since this was the most commonly used frequency, any distress call would be made in the frequency region of greatest traffic density. Thus there was the hope that such a call would have a good chance of being heard and acted upon. At the same time there was the possible serious disadvantage that a faint SOS might not be heard at all in the uproar created by numerous spark stations operating at or near this wave length. This dilemma has never been fully resolved, although later radio conferences have attempted to provide greater protection for the 500 kc frequency for distress traffic.[41] The shift from

spark to CW transmitters, to be described below, further alleviated this situation.

The London Conference also went on record as urging the compulsory installation of radio apparatus on board ships, the maintenance of a continuous radio watch, and the obligatory installation of emergency apparatus capable of being operated independently of the main station and its source of power.[42] It was felt, however, that it was beyond the competence of the Conference to make these proposals obligatory on the various national sovereignties; consequently the Conference urged that appropriate national legislation be enacted in the furtherance of these ends. The Conference did, however, set up different categories of ships and suggest the radio competence of each as guides to individual governments.[43]

An attempt was made as well to strengthen operator competence in the interest of both safety of life at sea and efficient handling of commercial traffic. Many countries were very lax in the granting of operator licenses, and it was with the intention of setting stricter standards that the Conference prescribed First and Second Class Certificates in terms of code speed, together with an adequate knowledge of radio rules and apparatus adjustment.[44] Reflecting lessons learned from the *Titanic's* sinking, the London Regulations were additionally concerned with the communication of weather reports, time signals, procedure to be followed when a distress signal was received, and placing the use of radio under the command of the ship's captain.[45]

On July 5, 1912, the representatives of forty-three countries signed the London Radiotelegraph Convention and Regulations; and of these, forty had ratified by July 1, 1913, when the instruments went into force.[46] The British delegation at the Washington Conference of 1927 reported that there had been forty-one ratifications and ninety-seven adhesions to the London Convention and that all, even those countries that had experienced little technological advance in radio, were keenly interested in international radio legislation that might concern them in the future.[47]

The 1914 London Conference on Safety of Life at Sea

Like the Radiotelegraph Conference of 1912, the sessions on Safety of Life at Sea were held in the shadow of the *Titanic* tragedy. Many painful inadequacies were patent when a great vessel could go down with the loss of 1500 lives on a busy North Atlantic shipping lane. Such matters as ice and weather warnings, navigation in dangerous waters, adequate numbers of lifeboats, ship design and stability, and

communications all took on an added significance. Reiff observes that "Sometimes, it seems, if enough people die, particularly in some dramatic way, societal reform is speeded up." He notes further, with regard to the loss of the *Titanic*, "It was also a great social and legal catalyst. Within virtually hours after the sinking, the United States dispatched two scout cruisers to the area to give warning of drifting ice. Five days after the disaster, on April 20, 1912, the Senate requested the President to enter into treaties with the other maritime powers to assure increased safety at sea."[48] On July 23, 1912, the United States Congress amended the Radio Act of 1910 to require an auxiliary power supply capable of at least four hours' operation, and to provide that a continuous radio watch be maintained.[49] The principles of both acts found their way into the 1914 Convention. Reiff further notes with regard to the Convention: "Provision was made for an internationally supported ice patrol in the North Atlantic, to be operated by the United States;" for "new obligatory rules for masters when meeting derelicts or ice; elaborate rules on the construction of vessels; radiotelegraphy for all merchant vessels; meterological information; lifesaving appliances and fire protection; safety certificates; and other pertinent matters."[50]

The Conference of 1914 went beyond that of 1912 in making the installation of radio equipment obligatory on certain categories of ships. Patterned on the American Radio Law of 1910 and its amendments in 1912, the Convention required (1) that ocean vessels carrying fifty or more passengers be equipped with radio having a range of at least 100 miles, and (2) that specified categories of ships maintain a continuous radio watch and carry auxiliary radio apparatus for use in emergencies.[51]

International regulation of maritime radio had come far in a decade only to have its promising advance slowed by the advent of World War I. As a consequence the 1914 Convention was never fully implemented, although individual countries profited from its provisions in framing their own radio legislation.

Chapter 3 From World War I through the Washington Conference of 1927

The Controversy over Spark

THE DECISIONS RENDERED by the London Conference of 1912 had greatly reduced the man-made anarchy on the air; and, while the number of fixed stations had increased, radio at the outbreak of World War I was still overwhelmingly a maritime service. But the next decade was to witness the emergence of new applications and progress in international regulation, private control, and technological development.

Technological Advance

Prior to and during World War I, several significant inventions added notably to the efficiency of radio. One was the rotary spark gap—a Fessenden invention—which produced a signal with a definite note or pitch that was much more readable through static and interference. Since each station using a rotary gap had a note of different pitch, it became possible for the skilled operator to single out more easily the particular station that he wanted to copy. The fixed gap previously in use had had a low, raucous note—if it could be called that—often indistinguishable from static discharges, the copying of which required as much intuition as it did knowledge of the code. Its passing was unmourned by the radio profession.

The rotary gap, however, was still but an improvement in the "spark" transmitter of that day, and the latter was a prodigal user of spectrum space. Mr. Irving Vermilya, a veteran of both early wireless and modern radio, has conservatively estimated that the "spark" transmitter occupied at least fifty kilocycles in the radio spectrum. A modern CW (continuous wave) vacuum tube transmitter can function within a three-kilocycle limit—a striking example of frequency conservation resulting from modern technology. The character of spark transmitters may be further illustrated by portions of the United States

Radio Law of August 13, 1912. In the interest of a "pure wave" it was stated that if the transmitter radiated on "two or more wave lengths, more or less sharply defined," the energy in the lesser waves should not "exceed ten percentum of that in the greatest."[1] Thus, in addition to its broad "fundamental" frequency, the spark transmitter was also subject to spurious emissions ("lesser waves") that the law took for granted, but which it tried to keep under some control. These "lesser waves" were a potent source of interference, particularly to near-by stations, and could not be eliminated as long as that type of transmitter was in general use.

The development of the alternator by Ernst F.W. Alexanderson, under assignment by General Electric, made possible the production of continuous waves that supplanted even the largest spark stations in use. From a one-kilowatt pilot model in 1906 he expanded the capacity of his machine to a 200 kilowatt job that was installed in the Naval station NFF at New Brunswick, New Jersey, in 1918—the most powerful radio station in the world.[2] Others were set up at strategic points and made the older spark stations obsolete for long-distance radio communication. Spark remained the work horse for maritime communications, however, until it was gradually replaced by vacuum-tube CW transmitters at both shore and ship stations, a fuller account of which will be found below.

More sensitive receivers were developed following the invention of the audion by Dr. Lee De Forest.[3] This remarkable invention completely outmoded the crystal, magnetic, and other early types of detectors and made possible the development of receiver circuits more sensitive and more selective than had been possible before.[4] Equally important was the development of De Forest's invention into a basic component of transmitting sets that were far more efficient and less wasteful of spectrum space than the spark transmitter. Dr. Irving Langmuir of General Electric is credited with this essential development -with modifying the De Forest audion, prior to World War I, by regrouping the elements, making possible the practical use of a very high vacuum and the high voltages necessary in a power amplifier.[5] Finally it was this tube, in its later development, that made possible the radio telephone and radio broadcasting. Of particular importance to maritime radio is the application of the radio telephone to safety of life at sea, which will be elaborated later.

Navy Control of Radio, 1917-1920

Unlike the general practice in other countries, telephone, telegraph, and radio communications in the United States were in private or

corporate hands, and not under government control. It was, therefore, a war emergency that led President Wilson to turn all radio over to the Navy when the United States became a belligerent in 1917. Since radio was still predominantly a maritime service the Navy seemed the natural agency to exercise custody during the emergency. The only private stations not taken over were those operated by amateurs, some 4000 in number. These were simply closed down for the duration their owners finding their way, for the most part, into the Navy and Signal Corps, where radio operators were in critically short supply.

Thus it was that the Navy found itself operating the stations of the American Marconi Company, a French station at Tuckerton, New Jersey, and those stations erected by the Telefunken Company,[6] as well as shore stations owned and operated by American interests. At the close of the war, the assets of the American Marconi company were purchased by the Radio Corporation of America, a subsidiary of General Electric and created for that purpose on October 17,1919.[7] The concluding of these agreements brought RCA into possession of virtually all the high-power stations in this country. During the next two years RCA's position was further strengthened by the acquisition through cross-licensing agreements of the patent rights owned by General Electric, Westinghouse, American Telephone and Telegraph, Wireless Specialty Apparatus Company, and the Radio Engineering Company. This expansive policy of RCA unfortunately involved it in difficulty with the courts, which charged it with unlawful restraint of trade.[8]

Relieving the Navy of its control over privately owned radio facilities had not, however, been a painless process. Secretary of the Navy Josephus Daniels had felt that continued naval direction was eminently desirable, and in the absence of a presidential directive to retreat[9] had proved unresponsive to pressures both public and private. The passage of either the Alexander or Poindexter Bills—the latter introduced at the urging of Secretary Daniels[10]—would have written into law the continued naval command of all radio in the United States. This prospect, disconcerting to both commercial and private interests, was initially dispelled by protests in the press and by friends of the radio amateur in a barrage of letters to members of Congress. The result was a joint resolution of both houses of Congress directing the Secretary of the Navy to remove forthwith the restrictions on amateur operation. It was announced on September 26, 1919, that the ban on amateur radio would be lifted, effective October 1st.[11] The return to private ownership of the commercial stations taken over by the Navy was formalized on March 1, 1920.[12]

Meanwhile there had been submitted to the Paris Peace Conference early in 1919 a memorandum prepared by an American communications expert (Mr. Walter S. Rogers) proposing a single new convention that would embrace all types of electrical communication, and which would be based on the needs of the general public as users. The disposition of German cables obscured full consideration of this proposal, but a Big Five resolution did go so far as to state that "the Five Allied and Associated Powers shall call as soon as possible an International Congress to consider and report on all international aspects of telegraph, cable, and radio communication, with a view to providing the entire world with adequate communication facilities on a fair, equitable basis."[13]

As a follow-up of this resolution a preliminary conference was held in Washington November 8th to 15th, 1920, during which time a convention was drafted for a "Universal Electric Communications Union," to which were annexed telegraph and radio regulations. The latter fell into two categories: (1) regulations for the fixed services and (2) regulations for the mobile (i.e., primarily maritime) services. A general conference to discuss these considerations was not, however, held partly because of U.S. opposition to imposing an international rate structure on its private communications companies, and partly because the other powers (France, Great Britain, Italy, Japan) were unwilling to have this matter dealt with in a separate protocol as proposed by the United States.[14]

The London Convention and Regulations of 1912 were clearly becoming outmoded by 1920, and realistic revisions were urgently called for in the maritime service, for example. It is true, as Tomlinson points out,[15] that with a technological revolution in the making in radio, any new regulations would soon have been inadequate. At the same time advance of the art called for a periodic re-examination of necessary regulations. If the world of radio were to wait for technological progress to settle down, there never would be periodic conferences to resolve new problems, and anarchy would be the result.[16]

Opening up the Short Waves

By the time the Navy had reluctantly relinquished its control over radio in the United States, the art was at the beginning of one revolution and on the verge of another. The first –a technological revolution made possible by the application of the vacuum tube to both receiving and transmitting curcuits; the second—the opening up of the so-called "short waves" (or higher frequencies) which made available for radio

communication a vast and hitherto neglected portion of the radio spectrum. From both of these developments maritime radio was, albeit slowly and reluctantly, to derive great benefits.

It had long been felt that only the low frequencies, or long wave lengths, were suitable for radio communication, and these ranged from 300 to 20,000 meters. This was understandable, for the experience with spark and alternator stations pointed unmistakably in that direction. Furthermore, the short wave region of the radio spectrum was unexplored, and the equipment to exploit these frequencies was yet to be invented. Consequently it was with the satisfaction of having disposed of a nagging problem that the United States Radio Law of 1912 relegated radio amateurs to the region of 200 meters[17]—a portion of the radio spectrum supposedly useless for communication purposes. To many amateurs of that day the 1912 Law had all the characteristics of a death sentence, but they nevertheless set about making the best of a bad situation. It is even possible that some inadvertently slipped above the 200-meter level, for accurate measuring instruments were hard to come by, and enforcement of the law was lax. After World War I and the restoration of amateur privileges, many moved down (meter-wise, that is), and in so doing discovered that they had been exiled to a bonanza—that with low power they could cover vast distances out of reach of even the most powerful fixed stations operating on the long wave lengths. Spanning the Atlantic in 1921 on 100 meters, American amateurs moved down still more until they reached 20 meters. Other amateurs in England, France, Italy, Argentina, New Zealand, and elsewhere, joined in, and by 1924 were spanning the globe with their signals. They had opened up the short waves and ushered in a revolution in communication.[18] To accomplish this it had been necessary to abandon the techniques of the days of "spark" which were totally inadequate in short wave work, and to devise new methods in the application of Dr. De Forest's invention. Commercial radio confronted the same set of problems, made all the more formidable by virtue of the extensive capital investment in equipment rapidly becoming obsolete.

Already the amateurs were demonstrating the accuracy of Marconi's prediction in 1922—that short-wave developments would render obsolete the powerful long-wave stations then in use. Licensed by their respective governments, the amateurs of many countries have consistently maintained emergency nets for disaster communications when conventional lines go out, and they have performed notable humanitarian services in hundreds of instances in the United States and elsewhere. They have, since 1927, been recognized in international telecommunication treaties

and have their own international organization, the International Amateur Radio Union (IARU), made up of some sixty national societies the world over.[19] In the maritime field, the American government permits amateur maritime mobile operation on merchant ships and on a number of naval vessels, including some submarines.[20]

The Washington Radio Conference of 1927

It had been specified at London in 1912 that the next general radio conference would be held in 1917, an expectation that was frustrated by World War I. Preliminary moves at Paris in 1919 and an exploratory conference at Washington in 1920 had pointed the way, but no worldwide conference met until 1927, when eighty countries, plus some sixty-four companies and private international organizations, sent their representatives to Washington.[21]

The Washington Conference met in the midst of a revolution in radio. The opening of the short-wave portion of the radio spectrum, made possible by the technological developments springing from the application of the vacuum tube and effectively exploited by the amateurs, enormously expanded the possibilities for medium and long-distance communication. At London in 1912 radio had been of concern primarily to the maritime service, but by 1927 a number of new services were demanding consideration for their needs. Most conspicuous among these were the broadcasting and aeronautical, with fixed services[22] and amateurs[23] also requesting frequencies or bands of frequencies in the radio spectrum. Both the broadcasting and aeronautical services demanded space in the traditional low-frequency portion of the spectrum formerly occupied only by the maritime service, and considerable conflict developed here as interference became a serious problem, and as aeronautical and maritime radio beacon systems interfered with each other. As late as 1939 this question was still unresolved.[24] Broadcasting in Europe after World War I had emerged in the low frequency (long wave) bands, and quickly demonstrated its incompatability with the ship and shore spark stations of the maritime service. Complaints of broadcast listeners, particularly in Great Britain, were many and vociferous, in answer to which the Postmaster General could only offer the limited consolation that more selective receiving sets would probably solve the problem.[25] On this point he found himself in an ambivalent position, since the Company was vigorously fighting all moves to eliminate spark transmitters in its ship and shore stations—for reasons not wholly incomprehensible from the economic point of view.

The Washington Convention and Regulations bore witness to a rapidly expanding terminology that reflected the growth of radio with its changing techniques. The needs of a new "mobile" service—the aeronautical—now required regulation and frequency allocations, a distinction hitherto held almost exclusively by the maritime mobile services. Reflecting the nature of the new day, the Convention of 1927 (effective, with the new Regulations, in 1929) embraced "all radio communication stations established, or operated by the contracting governments."[26] Likewise included in the Convention were those stations not open to public correspondence, since the problem of interference had become increasingly acute, and the contracting parties undertook to legislate so as to require observance of the Convention by all stations whether open to public correspondence or not.[27]

The major topic of discussion and source of dissension at Washington was the continued use of spark stations in the maritime service. It has already been seen that the transmitters of these stations were wasteful users of spectrum space and prolific sources of interference. The investment of shipowners and maritime stations in this equipment was, however, heavy, and they were reluctant to accept the financial burden involved in shifting to more modern instruments.[28] The old apparatus could not be modernized at modest cost; it would have to be replaced.

An added complication arose from the fact that a number of European countries had spotted their broadcast stations in the maritime frequency bands, and nourished the hope that if spark stations could be eliminated from the maritime service there would be more frequencies available for broadcasting.[29] The question of broadcast frequencies proved to be one of the thorniest encountered by this and later conferences, particularly after the long-range possibilities of shortwave broadcasting became apparent.

Both the United States and Holland urged the elimination of spark transmissions except for distress calls, and the United States, pointing out that in all new ship radio installations of American registry CW was used, favored the complete elimination of spark within a specified time limit.[30] Shipping interests and some radio telegraph companies, however, demurred, and argued for the retention of spark on the grounds that (1) the simplicity of spark equipment made it particularly advantageous in times of distress; (2) shipowners, as the first users of radio, had prior rights, (3) the estimated cost of replacement (of spark by CW) would run to 24 million dollars. It was further advanced that if spark were suppressed small vessels would feel the hardship most severely because of the added expense of new equip-

ment and the higher cost of hiring operators (why a CW operator would command higher wages than one using spark equipment is not clear); and that compulsory use of CW equipment would place both maritime radio companies and shipowners at the mercy of the radio construction companies.[31]

The influence of private companies (especially the Company) was sufficiently strong to prevent all but the most modest compromises. These may be indicated as follows: (1) spark was to be eliminated from the long wave bands below 375 kc (above 800 meters); (2) no new spark installations were to be made after January 1, 1930, except for transmitters of less than 300 watts power—thus insuring the continuance of medium-power spark sets on ships for an indefinite period, and providing broadcast listeners, it was hoped, with some protection from interference. High-power spark stations already in existence, however, would not be immediately affected; (3) spark was to be forbidden by 1940 except for ship stations of less than 300 watts; (4) no new spark equipment was to be installed in any land station, and spark was to be forbidden to all land stations after January 1, 1935.[32] Thus, except for voluntary changes by companies involved, there was the prospect of little relief from spark interference in the maritime service for ten years.[33]

Appalled by the prospective cost of replacing the radio equipment on their vessels, the shipping companies fought for the retention of spark at the Washington and subsequent conferences, and for twenty years were a major source of opposition to moves aimed at the elimination of inefficient, spectrum-wasting equipment. Spark transmitters occupied fifteen to twenty times as much space in the radio spectrum as a vacuum tube set, and with the vast increase in the number of ship stations—as a result of compulsory legislation—the continued use of spark had become an absurdity. It was also a danger to the safety of life at sea, since bedlam on the marine bands endangered reception of distress signals as well as reception of traffic attendant upon an impending or actual disaster at sea.

Reluctant to embrace the benefits apparent in the opening up of the short waves, the shippers clung to obsolete apparatus long after it had been abandoned by other radio services. After all, they said, it had worked well for twenty years. The cost problem of replacing existing equipment was real enough, but adopting the philosophy of the harness and whip makers when confronted with the growing number of automobiles provided no solution. They were, in fact, working against their own best interests in insisting on the continued acceptance of equipment that was useless on the higher frequencies and a source of

monumental interference on the lower. The result was that the shippers had ultimately to be forced to shift to a more effective mode of maritime communications. This proved to be a long process and one that continued for over thirty years after the Washington Conference.

Between the Washington (1927) and Madrid (1932) radio conferences there were many complaints about spark interference from European broadcasters who had become lodged in the low-frequency portion of the radio spectrum. In addition there were the objections of the International Air Traffic Association, which pointed out that the London-Paris air service was often jeopardized by interference from spark stations in the English Channel. These agencies urged the prohibiting of spark stations on frequencies interfering with their services, while the French government pressed for the complete suppression of spark stations of any power by not later than 1940. This proposal was not supported, however, by the French delegation at Madrid.[34]

At the Madrid Conference the delegation of the United States argued for the elimination, by 1940, of all spark stations except those of an emergency character. The delegation also declared that the arrangements at the Washington Conference were inadequate in preventing interference from spark stations even with the 300-watt limitation on power input. From the technical point of view spark was pronounced indefensible, and it was pointed out that 75 per cent of American ships had no spark transmitter of any kind The American position was supported by Canada, the USSR, and most of the European broadcast associations,[35] the latter hoping for an expanded area of operations if maritime spark stations could be removed from the low-frequency portion of the radio spectrum. Opposed was a bloc consisting (with France abstaining) of Great Britain, Germany, Japan, Holland, Denmark, Norway, and Sweden. The concern of these shipping nations seems to have been largely economic—the protection of a profitable capital investment in radio equipment that they were reluctant to replace with more modern instruments.[36]

The most articulate spokesman for the status quo, at Madrid as at Washington, was the International Shipping Conference. The latter claimed that replacement of spark stations would cost twenty-five million dollars, at the same time warning that ship-owners would be compelled to request increased power for their spark stations if the broadcast stations did not stay within their assigned bands.[37] The Madrid Radio Regulations did not settle the dispute, but stated that "The Administrations will endeavour to abandon as soon as possible type B waves, other than the wave of 500 kc s (600m)." It was additionally stated that spark stations might use six specified fre-

quencies: 375, 410, 425, 454, 500, and 1364 kc.[38]

At the Cairo Conference (1938) a flanking movement was directed against spark transmitters by proposing technical standards that the spark sets could not meet, but little success attended the effort.[39] The United States, as at Madrid, and with much the same support, sought a terminal date for spark operations except in distress cases. The opposition to change came, as previously, from those nations and organizations that had protested before. They pointed out that 8,000 of the 15,000 ship stations in operation were of the spark type, and they were declared to be essential in view of their sturdy simplicity and reliability. As on earlier occasions, the great expense of shifting to more modern apparatus was emphasized.[40]

The Madrid Regulations were modified to a degree at Cairo, however, in that the number of frequencies open to spark operation was reduced from six to three: 375 kc (direction finding only), 425 (traffic), 500 (distress, safety, traffic). An attempt to forbid traffic (spark) on 500 kc was unsuccessful.[41]

Due to the disruptive effects of World War II, nine years intervened before the convening of the next International Radio Conference. It was held at Atlantic City in 1947, and its decisions on matters of maritime communications offer much of interest and significance. A quick scanning of the Radio Regulations would seem to indicate that the spark problem had been dispatched forthwith, for it is stated that "The use of class B emissions is forbidden in all stations," with an exception stated for Australian ships which might use existing damped wave equipment temporarily on 425 and 500 kc when operating in close proximity to her coast. The same section went on to say: "However, it (spark, that is) is permitted for emergency (reserve) installations of ship stations and for lifeboats, liferaft and survival craft equipments."[42] Two of the spark frequencies allocated to spark stations at Cairo were reassigned to other services, 375 kc went to the aeronautical mobile and radio navigation services,[43] while the 425 kc frequency was included in the worldwide maritime mobile allocation.[44] In both cases some exceptions were made for European broadcasting, but none for spark, which was limited to distress calls and distress traffic on 490-510 kc. The withdrawal of these frequencies from spark use was reaffirmed in the Geneva Regulations of 1959, where spark was limited, on a distress basis only, to the 500 kc band.[45]

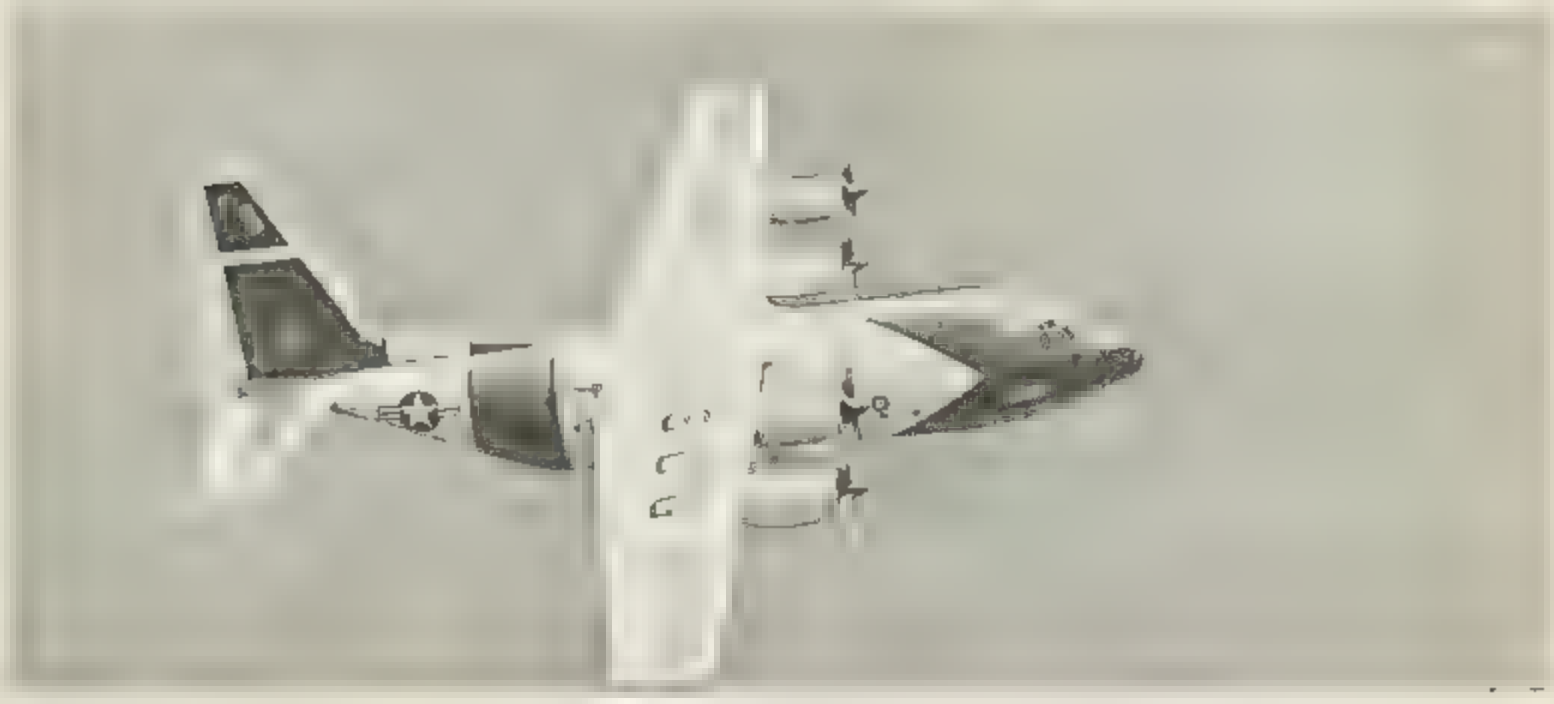
The Atlantic City Regulations, in again designating 500 kc as the distress frequency, stated that emissions preferably be A2 (modulated CW) or class B (spark).[46] This apparent encouragement of a condemned transmission mode is better understood in the light of a fur-

ther statement that a mobile station (ship in this case) might use any means available "to attract attention, make known its position, and obtain help."[47] All stations hearing distress traffic were forbidden to use the distress traffic frequency or to employ Class B emissions.[48] That is, while this mode of transmission was permissible to a ship in distress, other stations were not to cause interference by using spark.[49] To clarify the issue still further, ships with operable transmitters of A1 or A2 type (CW or modulated CW) were forbidden in an emergency to use class B (spark) transmitters except for distress signals and distress traffic.[50] While the Atlantic City statement that "The use of class B emissions is forbidden . . ." is hedged about by exceptions and special provisions, the gain in circumscribing the use of spark was very substantial. By 1947 spark was permitted on only one band of frequencies—that at 500 kc—and was authorized there only in cases of distress.

The latest attention to the question of spark in maritime communications is seen at the Geneva Conference of 1959. In the Geneva Radio Regulations there is reiterated the previous authorization that a mobile station in distress may attract attention to its plight by any means available, which includes the use of spark if available and necessary. A new proviso makes its appearance at this point, where it is stated that "in exceptional circumstances" a land station may aid a mobile station in distress by ". . . any means at its disposal."[51] That is to say, it could use spark, or broaden its radiotelephone or modulated CW (A2) emissions beyond the frequency tolerances specified and normally used.

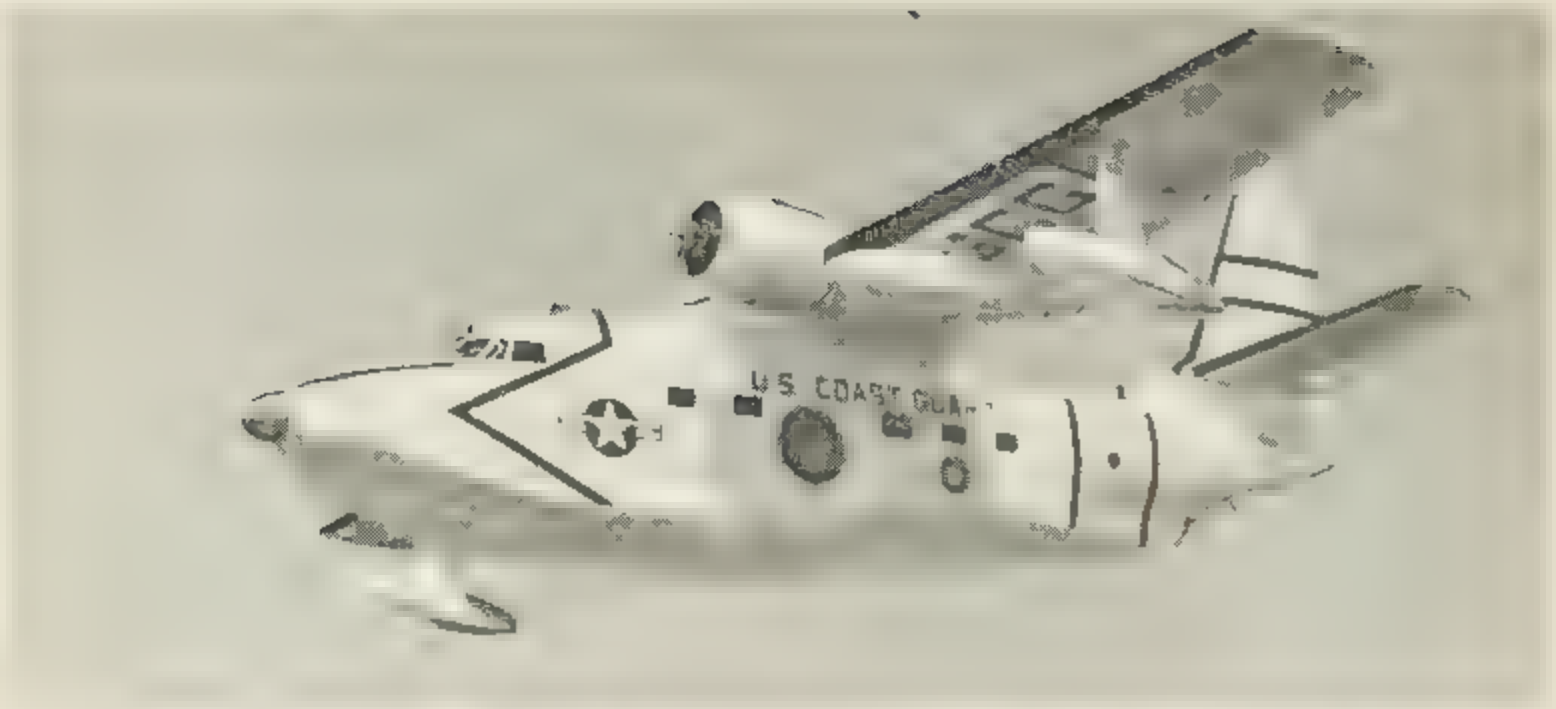
At long last it appears that the terminal date previously sought for spark transmitters has been designated by the Geneva Regulations, bringing to a solution a problem second in importance only to that of obligatory intercommunications. It is categorically stated that class B emissions will be allowed for distress calls and distress traffic only until January 1, 1966.[52] By this time some thirty-nine years will have passed during which attempts have been repeatedly made to eliminate from maritime communications a mode of transmission rapidly reaching obsolescence, increasingly inefficient in the light of advancing technology, and a wasteful user of spectrum space. As indicated, this long process has been marked by the slow attrition of frequency assignments to spark stations, by imposing stricter technical requirements which spark could not meet,[53] by the belated awareness on the part of shipping concerns that their own interests could best be served by communications equipment of modern design, and finally by outright prohibition.

USCGC *EVERGREEN* SERVES ON THE INTERNATIONAL ICE PATROL AND IS EQUIPPED TO PERFORM SPECIAL OCEANOGRAPHIC FUNCTIONS AS WELL



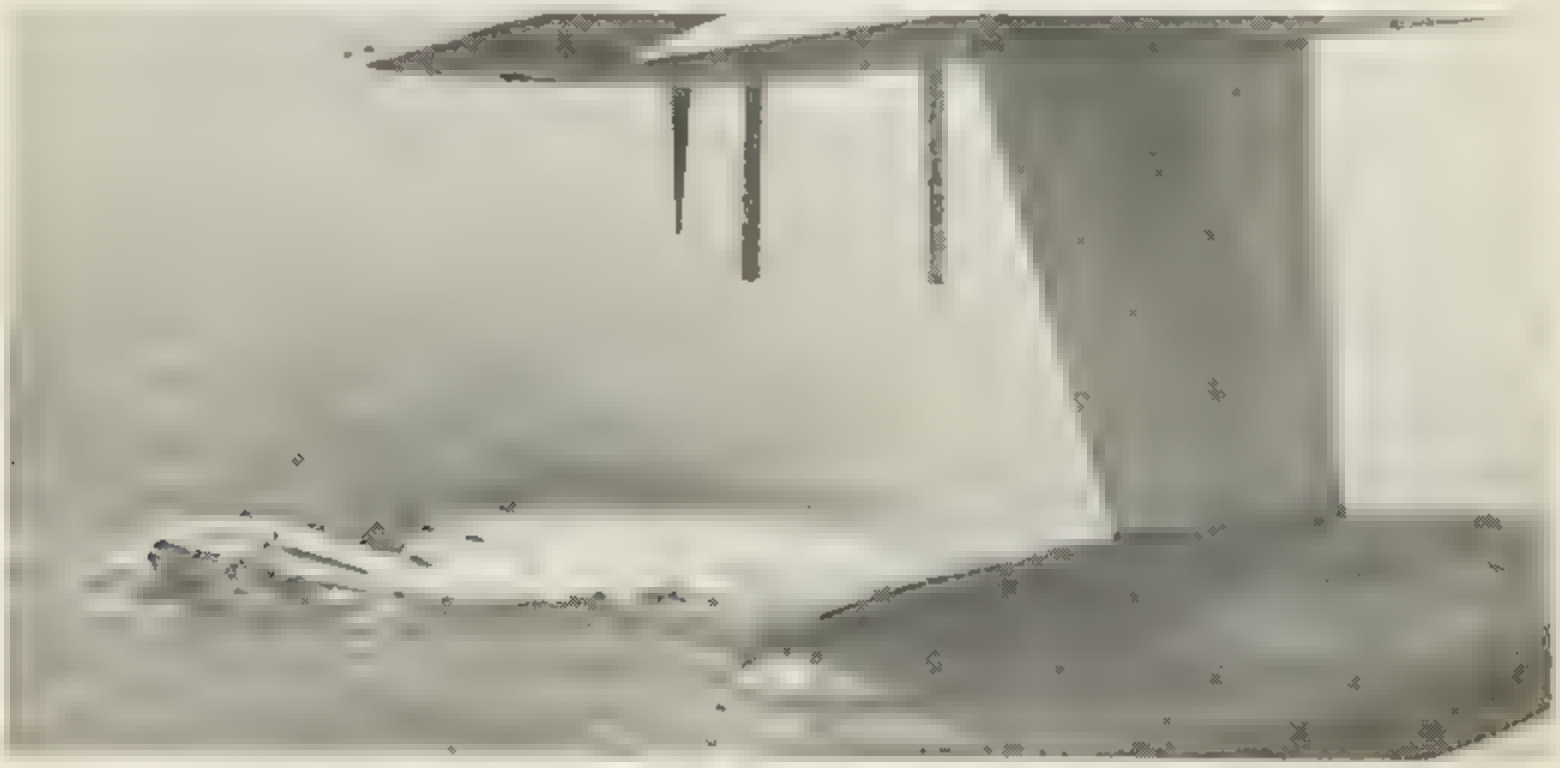
U S C G *HERCULES* PROP-JET USED FOR SAR AND ON INTERNATIONAL ICE PATROL. ITS VERSATILE RADIO EQUIPMENT ENABLES IT TO SERVE AS AN AIRBORNE RESCUE COORDINATION CENTER

USCG *SAR* AMPHIBIOUS HELICOPTER WITH RESCUE HOIST IN OPERATION THE RADIO ANTENNA IS SUSPENDED OUTSIDE THE AFTER SECTION, WELL ABOVE THE WATER AND BELOW THE ROTOR BLADES
U. S. Coast Guard Photo



COAST GUARD *SAR* AMPHIBIAN GRUMMAN ALBATROSS RADOME IN NOSE AND STUB RADIO MAST OVER PILOT'S COMPARTMENT ARE CLEARLY VISIBLE
U. S Coast Guard Photo

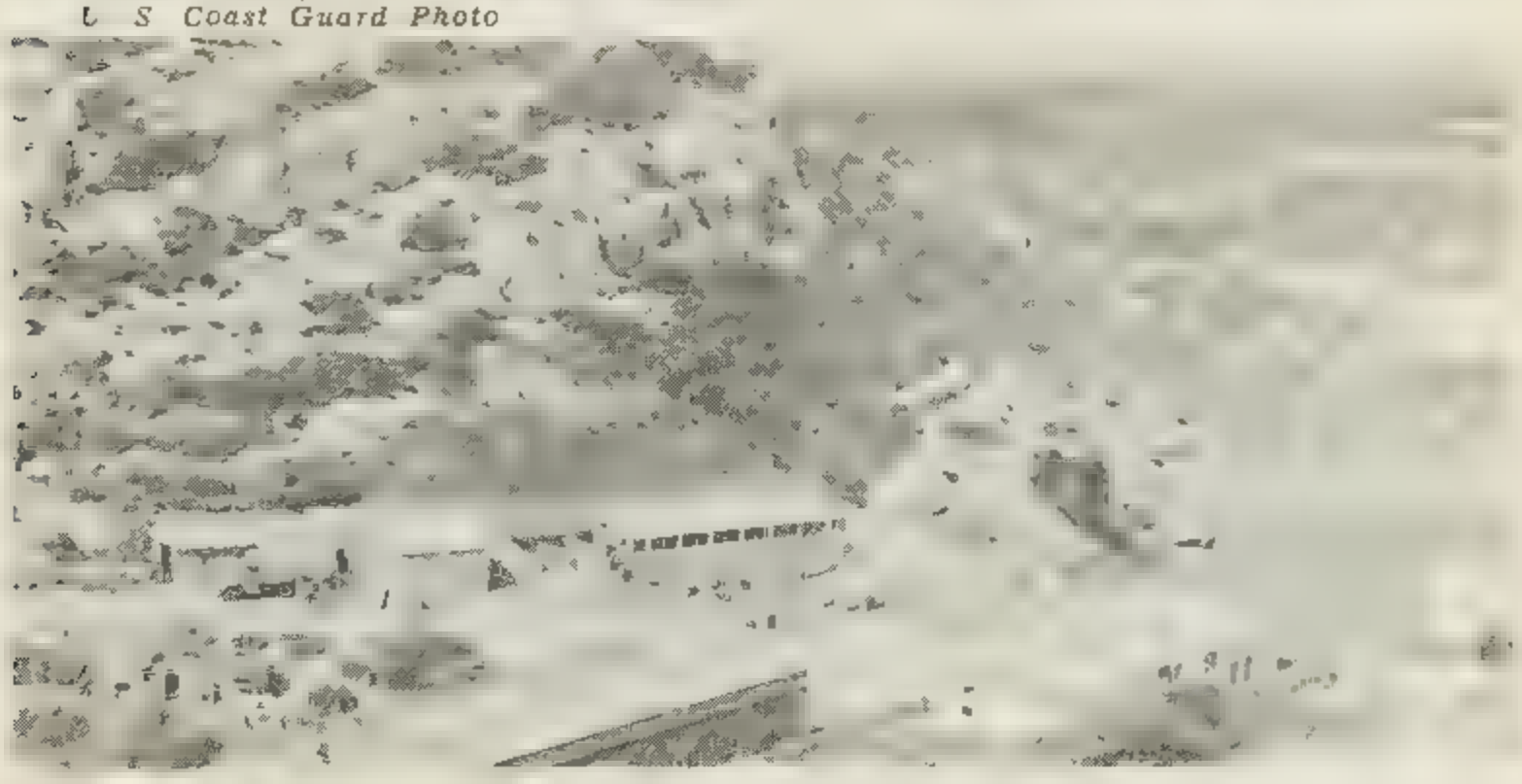
A USCG OCEAN STATION VESSEL USCGC *CAMPBELL* SOME HINT OF ITS RADIO AND RADAR VERSATILITY IS EVIDENT IN THE MANY ANTENNAS VISIBLE IN THIS PHOTO
U S Coast Guard Photo



S. S. *ANDREA DORIA* SINKING OFF NANTUCKET, JULY 26, 1956
Coast Guard Photo by United Press

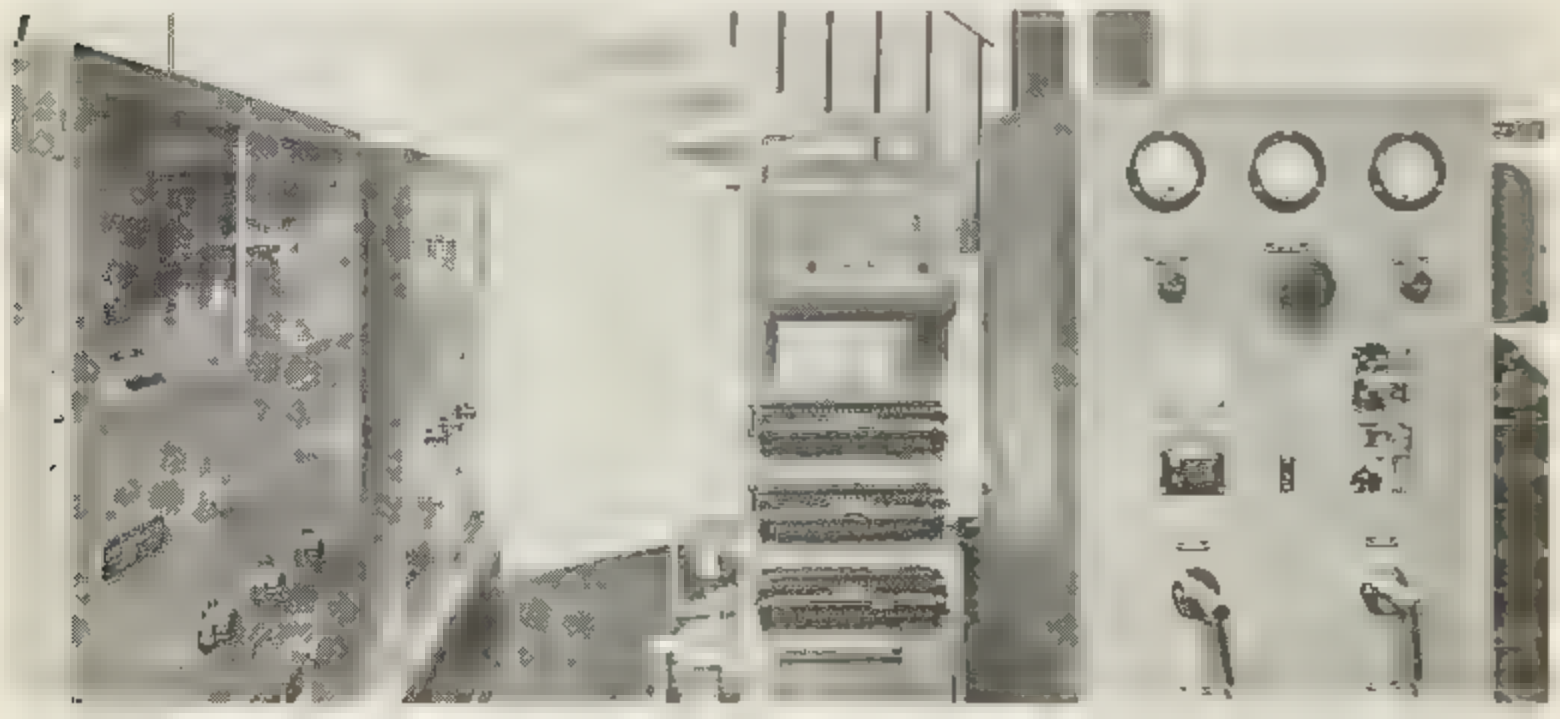
RADAR INSTALLATION ABOARD THE ILL-FATED *ANDREA DORIA*
Black Star Photo

BRITISH FREIGHTER *AMBASSADOR* WITH HEAVY LIST TO PORT IN NORTH ATLANTIC FEBRUARY 19 1964 USCGC *COOS BAY* FROM WHICH THIS PHOTO WAS TAKEN, WAS EFFECTING RESCUE OF CREWMEN
U S Coast Guard Photo



COAST GUARD *LORAN* STATION AT CAGLIARI, SARDINIA
U S. Coast Guard Photo

FORFST OF ANTENNAS AT THE AT & T TRANSMITTING STATION DIXON CALIFORNIA THIS ELABORATE COMPLEX PERMITS DIRECTIONAL TRANSMISSIONS OVERSEAS ON A WIDE RANGE OF FREQUENCIES
AT & T Photo by Sirlin



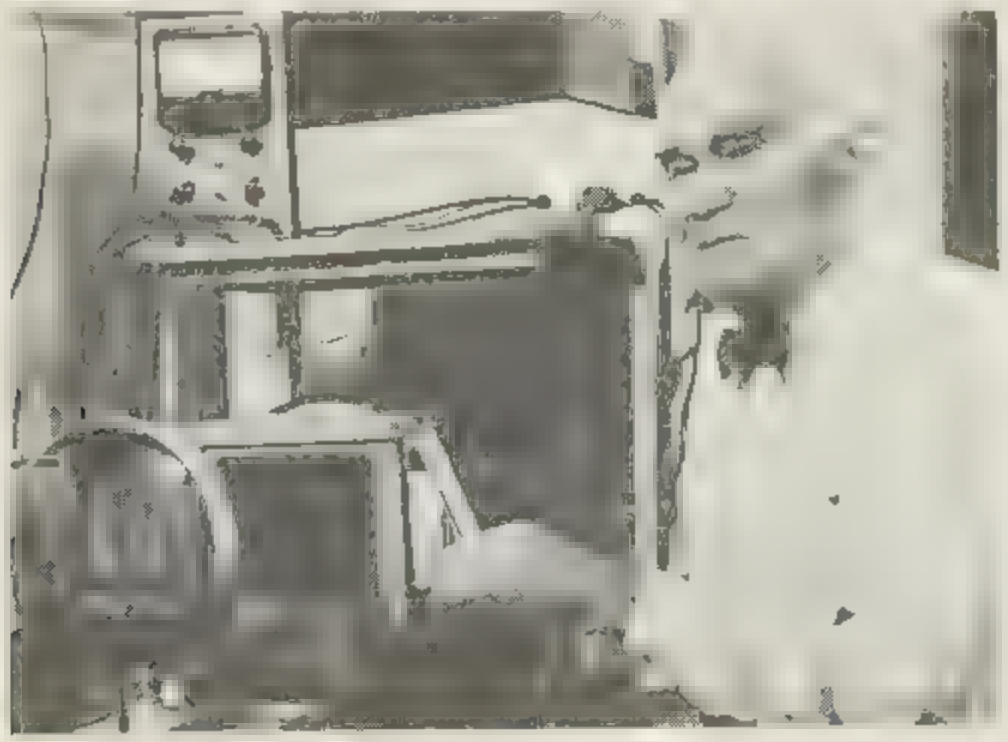
MARCONI BEACON TRANSMITTER IN FLAMBOROUGH HEAD LIGHTHOUSE 1938
Photo courtesy The Marconi Marine Co. Ltd

52-FOOT BARNATT LIFEBOAT USED BY THE ITALIAN GOVFRNMENT
Photo courtesy Royal National Life-Boat Institution, London

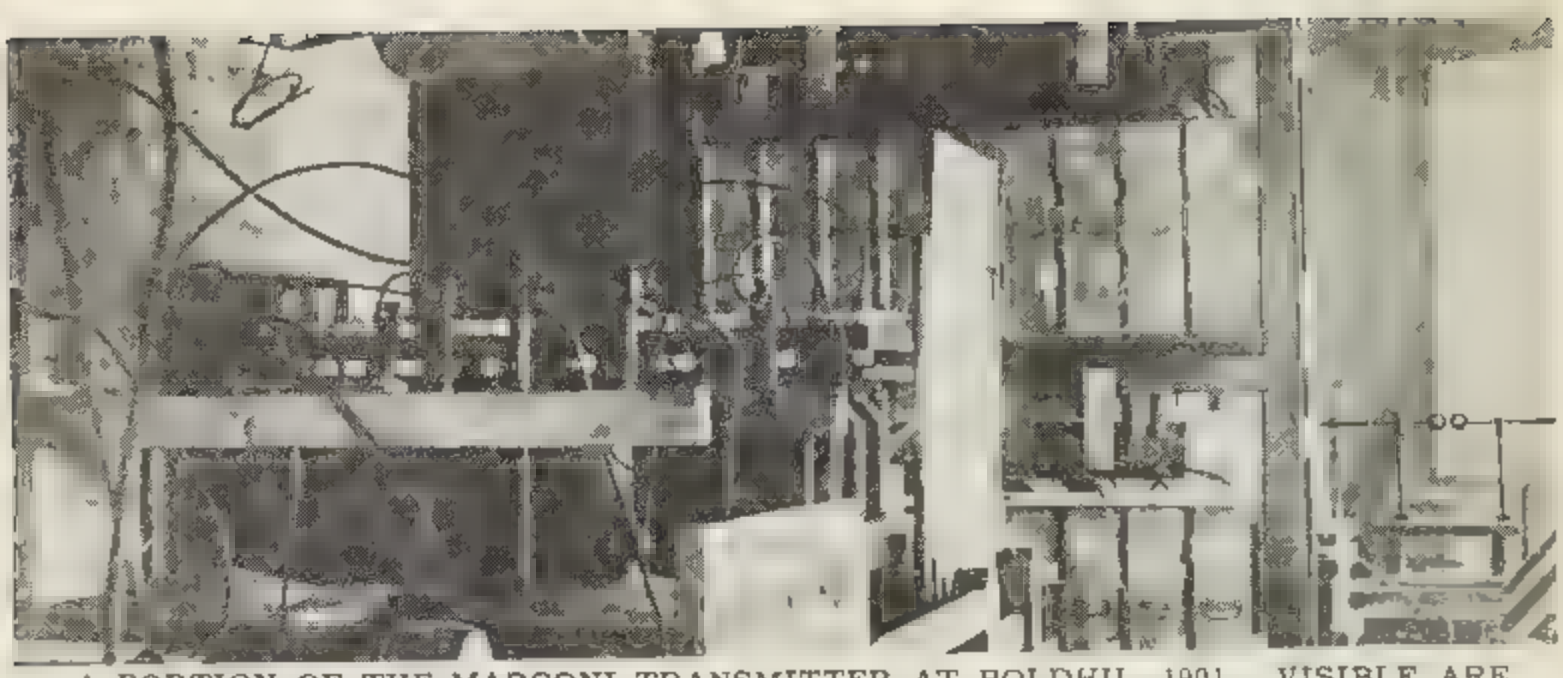
37 FOOT BRITISH MOTOR LIFEBOAT OF THE PAHLEY CLASS THIS BOAT USES A HORIZONTAL RATHER THAN A VERTICAL WHIP TYPE RADIO ANTENNA
Photo courtesy Royal National Life-Boat Institution, London

SIGNOR GUGLIELMO MARCONI WHOSE NAME IS SYNONYMOUS WITH EARLY WIRELESS
Black Star Photo

THE LATE SIR AMBROSE FLEMING, F.R.S ASSOCIATE OF MARCONI AND DEVELOPER OF THE VACUUM TUBE AS A RECTIFYING DEVICE
Photo courtesy the B.B.C. Broadcasting House



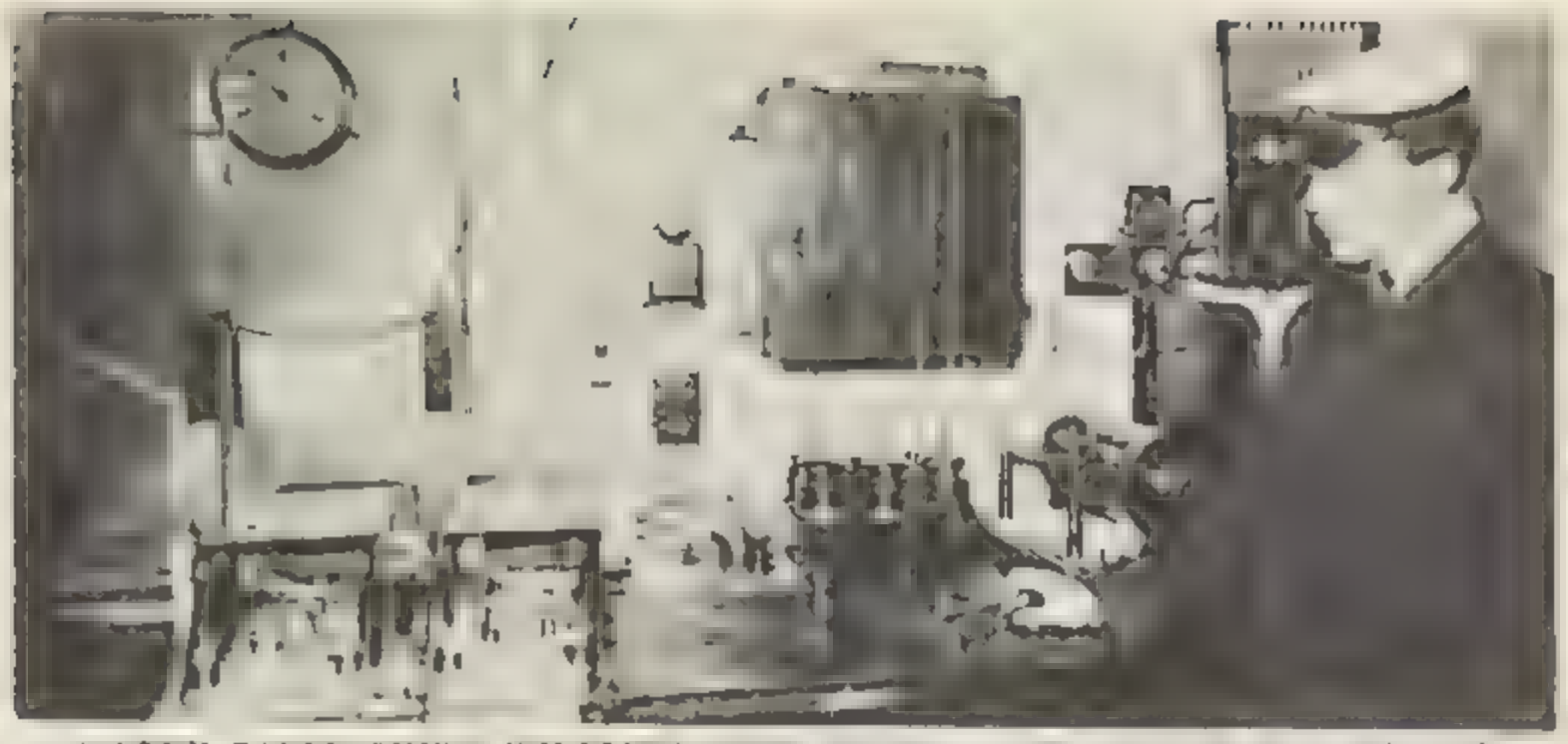
AN INTIMATE PHOTOGRAPH OF DR LEE DE FOREST
Black Star Photo



A PORTION OF THE MARCONI TRANSMITTER AT POLDHU 1901 VISIBLE ARE THE TRANSFORMERS, CONDENSERS, AND THE OPEN SPARK GAP
Photo courtesy The Marconi Marine Co. Ltd

FAN-SHAPED AERIAL AT POLDHU, USED TO TRANSMIT THE FIRST TRANS-ATLANTIC WIRELESS SIGNAL IN 1901
Photo courtesy The Marconi Marine Co. Ltd

ANTENNA STRUCTURE OF STATION WCC WELLFLEET, MASS., 1914 ANTENNA WIRES RARELY SHOW UP WELL WITH A BRIGHT SKY AS A BACKGROUND AND THE FLAT-TOP "Z" IN THIS CASE IS NO EXCEPTION
Original print supplied by Mr. Elmo N Pickerell This copy courtesy the W2ZI Historical Wireless Museum



A VERY EARLY SHIP'S WIRELESS THIS STATION ABOARD THE SS *PHILADELPHIA* c. 1900. VISIBLE ARE THE COHERER DETECTORS AND RECEIVERS. A MORSE INKER AND THE FAMILIAR SPARK COIL WITH THE OPEN GAP HERE ENCLOSED IN A TUBULAR CONTAINER
Photo courtesy The Marconi Marine Co. Ltd.

THE *TITANIC* IN SOUTHAMPTON HARBOR HER WIRELESS AERIAL IS DIMLY DISCERNIBLE STRUNG HIGH BETWEEN THE TWO MASTS
Black Star Photo

SHIP'S WIRELESS SIMILAR TO THAT ON THE *TITANIC* AS SEEN ON ANOTHER TRANS-ATLANTIC LINER OF 1912 MOST CONSPICUOUS ARE THE MARCONI TUNER AND MAGNETIC DETECTORS WITH THE EMERGENCY SPARK COIL TRANSMITTER PARTIALLY HIDDEN BY THE OPERATOR THE MAIN TRANSMITTER IS BEHIND BULKHEAD AT OPERATOR'S RIGHT
Photo courtesy The Marconi Marine Co. Ltd

MARCONI EQUIPPED SS *ARLANZA*, 1912 TO PROTECT OPERATOR FROM THE ROAR. THE MAIN TRANSMITTER IS HOUSED IN SILENCE CABINET AT RIGHT
Photo courtesy The Marconi Marine Co. Ltd

SHORE STATION BH IN 1910
OPERATED BY THE BOSTON *HERALD*. BH WAS AN EARLY "SHORE" STATION USING AN OPEN SPARK GAP TRANSMITTER AND A UNITED WIRELESS TELEGRAPH CO RECEIVER. THE OPERATOR IS MR. ARTHUR STOCKELBURG
Information and photo courtesy Mr. Ed G. Raser and the W2ZI Historical Wireless Museum

STATION NAA TRANSMITTER ROOM
A LITTLE KNOWN VIEW OF THE U S NAVAL STATION TRANSMITTER NAA. BUILT IN 1911 THE SIZE OF THE ALTERNATOR AND THE ENCLOSED ROTARY GAP MAY BE JUDGED BY A PARTIAL VIEW OF MAN STANDING AT LEFT
Photo courtesy of the W2ZI Historical Wireless Museum

Chapter

Highways in the Sky: Maritime Frequency Assignments and the Rules Governing their Use

The General Picture

IT WILL BE RECALLED that the Berlin Conference of 1906 had recognized the necessity for frequency assignments for the maritime service—the only service in existence at that time—and that two frequencies (wave lengths) at 300 and 600 meters had been designated. Wave lengths over 1600 meters were also specified for coast stations engaged in long-distance communication, while those between 600 and 1600 meters were reserved for military installations, i.e. "services not open to public correspondence."

At the London Conference of 1912 the maritime allocations were much the same, with the slight difference that in addition to 300 and 600 meters, the wave length of 1800 meters was specified. The simplicity of frequency assignments at that time contrasts sharply with the present, for "frequency management" has become an enormously complex field of engineering. The problem has become all the more difficult by virtue of the demand by individual sovereignties for more frequencies than the radio spectrum, even with constantly advancing technology, can accommodate. A rough indication of the increased attention given to frequency allocation at international conferences is evident in the space necessary for the allocation tables. At Washington (1927) one and one-half pages sufficed; at Madrid (1932) there were six; at Cairo (1938), twenty; at Atlantic City (1947), thirty-eight; while at Geneva (1959) there were sixty-four. These expanding allo-

cation tables covered, of course, all radio services of which the maritime was but one.

The expanding radio spectrum is also very significant in the story of frequency allocations, although this expansion has been unable to keep pace with the demands placed upon it. The spectrum has moved upward, frequency-wise, since the low frequencies (long wave lengths) in general use prior to the end of World War I represented essentially the limits of spectrum expansion downward. To clarify this portion of the argument it might be well to note that frequency and wave length are reciprocal: for example, 10 kc correspond to 30,000 meters, and 30,000 kc to 10 meters; while 50 kc correspond to 6000 meters, and 50 meters to 6000 kc.[1] Attention has already been called to the fact that wave lengths below 200 meters (or above 1500 kc) were regarded as useless for effective communication—a concept which the radio amateur was largely responsible for demolishing.

As a consequence the radio spectrum moved rapidly in the direction of the higher frequencies, as is indicated by the terminal point of frequency allocations adopted by successive conferences. At both Washington and Madrid the table ended at 60 mc (60,000 kc). At Cairo it jumped to 200 mc, and at Atlantic City to 10,500 mc. The most recent allocation table (Geneva, 1959) ends at 40 gc (gigacycles, or thousands of megacycles).[2] While there is a mobile and fixed frequency band at 36-40 gc, the present study at this point is concerned primarily with those frequencies currently in use for communication purposes by the maritime service, the highest of which is 243 mc.

Frequency Bands Allocated to the Maritime Service

Beginning with the Second Berlin Conference in 1906, the international community has accepted the necessity of determining radio frequencies on other than a national basis. As new services came into being, and as the radio spectrum expanded to make available higher frequencies capable of global performance, the need for international regulation became even more urgent. Any other approach, in effect, spelled chaos that would jeopardize the usefulness of an invaluable international natural resource. In recognition of the fact, however, that not all radio frequencies have global capabilities, the practice was adopted at Madrid of dividing the world into regions for allocation purposes. At that time the classifications were General, European, and Other. This process has been refined at subsequent conferences until the most recent administrative conference at Geneva (1959—as at Atlantic City in 1947) designates three Regions for allocation purposes.[3] Region 1 includes Western Europe, North Africa, and the

Soviet Union; 2, the Western Hemisphere (the Americas and Canada); 3, East, Southeast, and South Asia, along with most of Oceania.

This regional approach introduces flexibility and makes possible the assignment of many frequencies on a regional basis where a world-wide determination would not be feasible. Broadly viewed, the frequencies from 10 to 70 kc are designated as world-wide; those from 70 to 2850 kc, regional (except for 500 and 2182 kc, the international distress and calling frequencies); those from 2850 to 3500 kc, world-wide; and those from 3500 to 5480 kc, largely regional. From 5480 kc to 27.5 mc, all allocations are world-wide, these being the high frequency bands most capable of global coverage and hence not suitable for regional determination.[4] Attention should be called to a third world-wide emergency frequency—8364 kc—designated for the use of survival craft stations in both the aeronautical and maritime mobile services.

Allocations by the international radio conference define the bands of frequencies for use by the various services, but specific frequencies are assigned (for example, to ship and shore stations) in these bands by the various administrations. In the United States the assignments to non-military stations are the responsibility of the Federal Communications Commission. Military (Army, Navy, Coast Guard, Air Force) frequencies are assigned by IRAC (Interdepartment Radio Advisory Committee), on which the FCC is represented.

By way of summary it can be noted that internationally the maritime service is assigned fourteen frequency bands between 14 kc and 510 kc, sixteen between 510 kc and 3500 kc, and ten between 4 mc and 24 mc. In the VHF band a frequency at 156 mc (156-174 mc, with 156.8 specified for distress) is designated as an international safety and calling frequency for maritime mobile radiotelephone. The frequency 121.5 mc, while assigned to the aeronautical service for emergency use, may be employed by the maritime mobile service for safety purposes. For survival craft the 243 mc frequency is specified for international use. There is, then, a total of forty-two frequency bands assigned to the maritime service in the current allocations (Geneva, 1959), as compared to twenty-five at Madrid (those at Washington being not greatly different).[5]

Some Problems on the High Frequencies

It is in these high frequency bands (4 mc—27.5 mc) that the greatest difficulties have been encountered in attempting to reach world-wide agreement on allocations. Broadcasting in particular has been reluctant to yield to a rational program of frequency management as many

nations act under the compulsion to bombard other nations with offerings ranging from native folk songs to outright propaganda. The Cold War has exacerbated the problem with jamming (by the Soviet bloc nations in particular) and out-of-band broadcasting that imperil the effectiveness of other services in assigned frequency bands. To this confusion has been added the bedlam of new broadcast stations put on the air by the late comers to the international community in Africa, East Asia, and the Middle East.

Instances can be cited, as well, where a frequency assigned to a maritime coastal station has been rendered useless by the intrusion of another service operating in derogation of the ITU allocation table. For example, it was recently demonstrated to the writer at one of our larger maritime coastal stations that a Soviet teleprinter circuit was operating on one of the station's assigned frequencies, rendering the latter completely unusable. All efforts to negotiate the removal of the intruder from the affected frequency proved unavailing.

All the bumps and roadblocks on the highways of the sky are not, however, man made. Those of natural origin can prove equally if not more frustrating. The latter derive from propagation phenomena that determine whether a given signal will be reflected from the ionosphere and returned to earth as readable intelligence, or be lost in space. Communication on the high frequency bands is thus dependent on the reflecting properties of the ionosphere, while the latter, in turn, are closely linked to the sunspot cycle. As this is being written (1964), sunspots are at the low point in their eleven-year cycle, and under the heading of the IQSY (International Quiet Solar Year—also called the Year of the Quiet Sun) intensive international observations are going forward to probe the mysteries of these solar phenomena. In like manner, one area of investigation during the IGY (International Geophysical Year—1958) was the behavior of the solar cycle at the height of sunspot activity. The relevance of this to the present study is that with the latter at low ebb, the ionosphere in large part loses its capacity to reflect radio waves on the higher frequencies. As a consequence the higher maritime (and other) frequencies become virtually useless for communication This could mean, by way of illustration only, that the frequencies from 15 mc to 27.5 mc could not be used with any considerable degree of reliability and that the various radio services would therefore be compelled to concentrate their long-haul communications on frequencies farther down in the spectrum. This would entail more congestion and increased interference on the overloaded frequencies. In effect, the upper portion of the high frequency spectrum shrinks, disabling circuits that several services nor-

mally maintain on these bands. For this situation time is the only cure. Conditions will improve gradually until, by 1969-1970, radio wave propogation will once more be normal.

Rules of the Road on the Highways of the Sky

1. *International and National Prescriptions*

An international telecommunication Convention, which resembles a constitution in governmental processes, prescribes the structure of the Union and its relationship to other international bodies, and lays down general rules or principles relating to the international telecommunication community. Among these may be noted as typical the sections covering secrecy, the priority of telecommunications concerning safety of life, intercommunication, harmful interference, and false or deceptive distress calls. The Radio Regulations, on the other hand, are analogous to legislation on an international scale and are concerned with rules for all radio services, including the maritime mobile and others.

At the conferences on safety of life at sea the rules dealing with radio in its distress and safety role are still further elaborated—within the framework of the General Regulations. Individual national administrations may, in their regulations, carry the detailed prescriptions still further in applying them to the various services.[6] They can (and some do), for example, apply more exacting standards to the licensing of stations and operators. The strictness with which the various administrations follow this practice varies considerably.

2. *Rules of General Application*

All administrations are enjoined to preserve the secrecy of radio communication which, by its very nature, is easily intercepted by third parties. Hence coded transmissions are used by military stations, and scrambling devices are available to prevent the interception of radiotelephone interchanges. In the licensing section of the Geneva General Regulations (1959) it is stated that ". . . the license shall provide. . . that. . .the reception of radiocommunication correspondence, other than that which the station is authorized to receive, is forbidden, and that in the case where such correspondence is involuntarily received, it shall not be reproduced, nor communicated to third parties, nor used for any purpose, and even its existence shall not be disclosed."[7] The occasional violations of stations under United States jurisdiction are handled appropriately by the Federal Communications Commission.

Interference, inherent in the nature of radio in contrast to telephone

and telegraph land lines, presents problems as old as the art itself. The causes may be natural, as presently created by the sunspot cycle, severely affecting the heavily used, saturated frequencies. Or they may be man made—presumably amenable to rational treatment, but, as Chapters I and II of this study have revealed of the problem in its early stages, necessitating strict measures. Today broadcasting offers the most obvious illustration of jamming; and, inaugurated and maintained as a facet of national policy, it remains singularly unyielding. By established practice during war those countries having the capability intercept or jam the radio signals of the enemy. Nor in the Cold War is the Soviet jamming of high frequency broadcasts the sole example, for the Chinese People's Republic allegedly has jammed Soviet broadcasts to China in retaliation for similar Soviet treatment of theirs.[8]

In language almost identical to that of previous Regulations, the Geneva Regulations of 1959 define "harmful interference" as "Any emission, radiation or induction which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radiocommunication service operating in accordance with these regulations."[9] The Geneva Convention, on the other hand, declares with respect to interference that "All stations, whatever their purpose, must be established and operated in such a manner as not to result in harmful interference to the radio services or communications of other members (of the ITU) . . ."[10] That this injunction may be honored in the breach as well as in the observance is illustrated in the example cited earlier in this chapter.

After asserting that "All stations . . . must be operated in such a manner as not to result in harmful interference . . .," in the same vein but not in the same article the Convention hastens to add that "Members . . . retain their entire freedom with regard to military installations of their army, naval, and air forces."[11]

The maritime and aeronautical services, in view of the great urgency attending distress on the sea or in the air, enjoy the use of certain exclusive frequencies denied to other services, thus largely solving the problem of interference (except, possibly, from their own service).

The reduction of interference is, however, remote as an overcrowded spectrum confronts increasing demands for space. The greatest relief would result from a prolonged period of peace that would reduce the demands of the military for the high frequencies, since of all the users of valuable spectrum space it is one of the most voracious. Similarly, a drastic reduction in the number of high frequency broad-

cast stations used for propaganda purposes would release frequencies badly needed for other services. But the likelihood of such relief is scant.

With respect to distress calls the injunctions are absolute, unequivocal, and without exceptions. Article 38 of the Geneva Convention states that "The international telecommunication services must accord absolute priority to telecommunications concerning safety of life at sea, on land, or in the air, and to epidemiological telecommunications of exceptional urgency of the World Health Organization." In order that no doubt may prevail it is further asserted in Article 48 that "Radio stations shall be obliged to accept, with absolute priority, distress calls and messages regardless of their orgin, to reply in the same manner to such messages, and immediately to take such action in regard thereto as may be required." The procedure for transmitting a distress call by radiotelegraph or radiotelephone is set forth in detail in the General Regulations,[12] and should include (in addition to the international distress signal—SOS for radiotelegraph, MAYDAY for radiotelephone) identification of the station in distress, its position, the character of the emergency, and the nature of assistance desired. All stations operating on the distress frequency (e.g., 500 kc), on hearing the distress signal, are to stop transmitting immediately and to stand by—until the emergency has passed; or, at the appropriate time, they may call in to offer such assistance as they may be capable of rendering. Maritime stations are required to be designed for break-in operation (radiotelegraph, that is) so that a transmission may be quickly stopped at any time, either by the operator's hearing the SOS himself between keying intervals, or by a break-in from the other station being worked, requesting him to stop transmitting. If the ship in distress is unable to direct rescue operations, the nearest vessel with radio capability may do so. This whole process has been greatly systematized in the Atlantic through the AMVER system operated by the United States Coast Guard and described in Chapter VII.

The auto alarm, designed to respond automatically to a prescribed distress signal[13] (and to reject other signals and bursts of static), is required on vessels carrying less than three operators, i.e., ones on which a continuous radio watch is not maintained. In this way even a one-operator ship will be alerted by a distress call, the operator will be summoned to his instruments, and it can be quickly determined whether or not his vessel is in a position to render assistance to the ship in distress. The auto alarm signal is, of course, followed by the particulars noted above in the prescribed distress procedure. In addition, all ships are urged to take bearings, if possible, on the position

indicated by the distress signal so that as little time as possible will be lost in proceeding to render assistance.

The international prescriptions for the use of radiotelephony in the maritime service are found in Articles 32-36, with Section VIII, paragraph 40, describing the alarm signal for this service.[14] The alternating audio tones of this signal are so distinctive and unmistakable as immediately to attract the attention of any operator monitoring the 2182 kc distress frequency.

The Urgency and the Safety signals[15] are second in importance only to the distress signal. The Urgency signal indicates a message involving the safety of a ship, aircraft, or person and has priority over all other communications except distress. Consisting of the group XXX repeated three times, followed by the call letters of the sending station, it is transmitted on 500 kc. On the radiotelephone frequency of 2182 kc the Urgency signal consists of the word PAN repeated three times and followed by the call, and then by the transmission of the Urgency message.

The Safety signal, which indicates the transmission of a message involving navigational safety or important meteorological warnings, is normally sent on one of the distress frequencies. Where practicable, however, the Regulations urge that the working frequencies be used. In radiotelegraphy the Safety signal consists of the group TTT thrice repeated, while in radiotelephony it is the word SECURITE similarly repeated. All stations hearing the Safety signal are expected to listen until it is clear that the message does not concern them (i.e., it might warn of a derelict far off the course of the vessel intercepting the message).

Further to increase the safety of life at sea, maritime mobile stations guarding the 500 kc distress frequency are required to observe silent periods twice each hour, at x hours 15 minutes and x hours 45 minutes, G.M.T. (Greenwhich Mean Time), the operator using either a loud speaker or headphones.[15] For the watch on the radiotelephone distress frequency of 2182 kc, the listening periods are designated as x hours 00 minutes and x hours 30 minutes, G.M.T.[16]

Other rules may be briefly noted, most of which are self-explanatory. In order to keep interference at a minimum, maritime mobile stations are required to limit their power input so that it is adequate but not excessive. If, for example, a large liner were to use its 10,000 watt transmitter for harbor communications, it would do so in gross violation of existing regulations. It is also required that all stations operate on the frequencies assigned to a given service, and within the frequencies defined for various transmission modes and frequencies.

Frequency tolerances for the entire radio spectrum are defined in the General Regulations.[17] The transmission of frequency standards by a number of stations such as the National Bureau of Standards station WWV[18] makes it possible for all others to check the accuracy of their frequency measuring equipment and to keep the emissions of their transmitters within the prescribed bounds.

Transmitting stations are required to identify themselves periodically by using their calls and must avoid using false or deceptive signals. A mobile station may be inspected by appropriate authority of a government it is visiting, but in view of the fact that these requirements are the international minima, the Regulations enjoin members of the Union (ITU) ". . . not to impose upon foreign mobile stations which are temporarily within their territorial waters . . . technical and operating conditions more severe than those contemplated in these Regulations."[19]

Ships are divided into three categories in terms of the international public correspondence service they provide. The first maintains a continuous service (i.e., at least three operators available); the second maintains only a limited service of eight or sixteen hours (one or two operators), the third maintains a service that is " . either shorter than that of stations in the second category, or is not fixed by these Regulations."[20] The hours of service provided by stations in the second category are prescribed in terms of zones (areas) and available operating personnel, with two columns—one for eight hours, the other for sixteen. A periodic schedule is defined enabling other stations in the maritime mobile service to know, by G.M.T., the exact hours when such a ship station may be contacted.' Establishing communications with ships of the third category is a hit-or-miss procedure unless the administration concerned prescribes and publishes specific hours of operation. Mobile stations in the maritime service are required to have available for ready reference lists of stations and their call letters. In order to expedite traffic exchange between ships and between ship and shore stations, a uniform message form is used, and priorities for message handling are described in detail. The abbreviations used in radiotelegraphy are described in the section following.

The rules of the road for the maritime radio service are clearly extensive and detailed, but at the same time they are the minimum standards set up by the international community through the instrumentality of the ITU. As previously indicated, these rules may be augumented by the Safety of Life at Sea Conference and by the various national administrations exercising jurisdiction over their own ship and shore stations.

3. *Licenses and Call Letters*

In the General Regulations it is stated that "No transmitting station may be established or operated by a private person or by any enterprise without a license issued by the government of the country to which the station in question is subject."[22] The nature of information required is stated in general terms for both ship and shore stations. If necessary there may be added to the text of the license in the national language ". . . a translation of the text in a language widely used in international relations."[23] The operation of such a licensed station must be in the hands of a properly certified operator[24] whose qualifications are determined by the administration granting the license (certificate). In both cases the issuing administration may make the licensing process as exacting as it deems necessary. A casual monitoring of the more heavily used maritime frequencies would seem to indicate that national standards vary somewhat in this respect.

Effective maritime radio communications require that stations be readily identifiable; and, to achieve this, call letters ("signs") are assigned to all stations. In the early days of wireless this was a very casual process, with individual owners or companies simply selecting their own calls. National and international regulations were lacking, and not only was there no uniformity, but the possibilities for duplication and confusion were present as well.

Reference was made earlier in this study to Marconi's pioneer station at South Wellfleet, the original call of which was CC. A list of shore stations in the United States in 1908[25] indicates no call of more than two letters, some of which were obviously derived from the station location: e.g., Babylon, Long Island, was BA; Cape Hatteras was HA; and Galveston, Texas, was GV. Most unusual of all, however, were the one-letter calls such as D for Portland, Maine; G for Galilee, New Jersey; and Q for Quogue, Long Island. A similar list[26] of United States Naval and Canadian shore stations, also in 1908, indicates that the United States Navy had adopted a logical series of two-letter calls beginning with the letters P to U inclusive. In two cases calls assigned to United States Naval shore stations were identical to those allocated to Canadian Government shore stations. Fire Island, New York, and Point Amour, Labrador, both had the call PR, and the call SD was assigned both to Culebra, West Indes, and Sable Island, Nova Scotia. Anomalies of this sort were eliminated by the London Radiotelegraph Conference of 1912, which prescribed that all radio stations were to be assigned calls consisting of three or four letters, the responsibility for which was delegated

to the Berne Bureau of the International Telegraph Union.[27] The latter was additionally instructed to publish periodic lists of radio stations of the world, a function currently performed by the ITU.

The International Call Sign Series,[28] starting with "A" and ending with "Z", allocates three-letter calls in blocks to the various administrations, the first letter, or the first two letters of which, indicate the country or administration. The United States, for example, has been assigned the letter groups AAA-ALZ, KAA-KZZ, NAA-NZZ, and WAA-WZZ; Germany, DAA-DTZ; Japan, JAA-JSV. The administrations are requested not to assign calls which might be confused with the distress signals or the "Q" signals.[29] Exceptions and special cases are noted and instructions given for dealing with them.[30]

The Q Code is the international shorthand of radiotelegraphy, and has evolved over the years in response to the need for a system making possible the transmission of required information through the use of as few characters as possible. Three-letter groups are used, each beginning with the letter Q, and of these there are three categories or series: one, reserved for the aeronautical service, assigned the series QAA to QNZ; a second, reserved for the maritime service, with the series QOA to QQZ; and a third, for use by all services, with the series QRA to QVZ.[31] The latter group will illustrate the scope and character of the Code.[32] In this series there are over 200 items, each conveying or requesting information which, if spelled out in detail, would be cumbersome and time-consuming. For example, QRE? asks, "What is your estimated time of arrival at . . .?" The answer might be, "QRE Norfolk 1700," indicating the queried vessel's estimated time of arrival at Norfolk as 1700 hours, G.M.T. The saving of time and the economy of spectrum use in this way are obvious. Professional operators come to know the Q signs instinctively and use them with the same facility employed in plain language communication.

4. *Radiotelephone in the Maritime Mobile Service*

By the late 1920's the radiotelephone had developed to the point at which it was being more and more widely used by small craft such as trawlers and tugs, and by shore stations set-up to handle traffic with such craft. This was especially true of the North and Baltic Sea regions where the density of maritime radiotelephone traffic became—and remained—a severe problem. The Madrid Telecommunication Conference (1932) took cognizance of this situation to the extent of making special allocations to the service in the European Region. Frequencies were assigned between 1530 and 2000 kc,[33] but the total number of kiloycycles so designated was only 260—far too few to meet

the need. As a consequence the maritime radiotelephone traffic tended to spill over into the frequency bands allocated to other services[34] such as broadcasting, fixed, and mobile. By 1938[35] regional conferences brought a nominal degree of adjustment, but the pressures on limited spectrum space remained severe. A similar but less severe problem also developed on the Great Lakes, with the United States and Canada reaching an agreement in March 1939.[36]

The proliferation of radiotelephone stations in the maritime service can be accounted for in part by the compactness of the apparatus and its adaptability to small vessel use. Even more significant, however, was its simplicity of operation, for which the training of a radiotelegraph operator was not needed. Rules had to be established, to be sure, and they have become more specific and exacting with each successive conference on radio and on safety of life at sea. Essentially, however, all that is necessary to put a radiotelephone on the air is to pick up the microphone, press a button, and start talking.[37]

At the Atlantic City Administrative Conference of 1947 the allocation of bands open to maritime radiotelephone was much more generous, with blocks of frequencies assigned from 1605 to 3800 kc. Specific provision was made to protect the international radiotelephone distress frequency of 2182 kc, but in the region below 4000 kc and above 1605 kc, a total of 1766 kc was assigned.[38]

Meanwhile a new problem had intruded itself into this portion of the radio spectrum with the development during World War II of LORAN.[39] The Northeast Atlantic Standard LORAN Chain had stations on Iceland, the Faroes, and the Hebrides. Its daytime ground wave coverage extended from Iceland half way to the southern tip of Greenland, down almost to the 50th parallel, thence northeast across Ireland, Scotland, the North Sea, southwestern Norway, and north to about the 68th parallel. The nighttime skywave coverage was most extensive, reaching much of Western Europe from southern Spain to the northern tip of Norway, and including the several adjacent seas.[40] Operating in the band 1900-2000 kc (centered at 1950 kc), this system caused a considerable amount of interference to ship and shore maritime stations that were the heaviest users of frequencies in this portion of the spectrum.

In the Atlantic City Radio Regulations (1947) the Northeast Atlantic Standard LORAN Chain was temporarily authorized in the band 1900-2000 kc until July 1, 1949, provided all possible steps were taken to minimize harmful interference from LORAN transmissions. The Regulations further stated that a special Administrative Conference might be called to review the matter if three of the interested countries

should declare that suitable aids to radionavigation could not be made available by July 1, 1949, in the bands allocated for the radionavigational service.[41]

The proposed Conference was held at Geneva in January 1949, on the recommendation of Canada, the United States, the United Kingdom, and the Netherlands.[42] A month's discussion of the problem revealed a three-sided division over the question of LORAN interference to maritime service in the area. One group maintained that the continued operation of LORAN was essential both to shipping and to aviation. (The representative of the International Civil Aviation Organization supported this view). The second group accepted the continuance of LORAN operation provided that ". . . some means could be found that would share 'more equitably' the 'burden' resulting from its harmful interference . . ." The only ones demanding the absolute prohibition of LORAN operation were Poland and the USSR, who declared, in part, "Loran is needed for the military aircraft of the U.S.A. (in carrying out a policy) . . . the final aim of which is to establish world wide Anglo-American domination by force. . . .Their purpose (the LORAN stations) is to provide a service for mass crossings by U.S.A. Air Force formations to the European Area."[43] It is interesting to note that at the Region 1 conference (summer of 1949) the countries most closely affected by LORAN interference signed the plan of frequency allocations and registered no reservations on the LORAN system.[44]

The Geneva General Regulations (1959) similarly gave some attention to this perennial problem of the Northeast Atlantic LORAN System, noting its temporary authorization and further stating that ". . . the establishment and operation of specific LORAN stations shall be the subject of special agreements among administrations having operations that would be affected."[45]

At Geneva the allocations of frequencies to the maritime radiotelephone service in Region 1[46] generally followed the pattern laid down at Atlantic City, except that the assignments started at 1625 instead of 1605 kc, and were defined in blocks up to 3800 kc. The chief difference in the two allocations was in more specific assignments to different types of maritime service, with frequencies designated for ship-to-ship, ship-to-shore, and coast stations.[47] The total number of kilocycles assigned was about the same as that at Atlantic City, but the separation of types of service frequency-wise was expected to result in reduced interference.

In the high frequency bands suitable for long-haul traffic, the carrier frequencies for ship radiotelephone stations (Geneva allocations) are in

six bands at 4, 6, 8, 12, 16, and 22 mc, with double sideband calling frequencies in separate columns.[48] Since a single sideband station carrier occupies less than half the space of a double sideband one, the spectrum conservation is obvious. There is also the fact that single sideband is characterized by a superior signal for a given power input, and is less subject to some types of fading. High frequency radiotelephone transmitters are found on the larger vessels with multiple installations and are used for commercial purposes as well as for passenger convenience.

Coast radiotelephone stations in the exclusive maritime mobile bands occupy five blocks of frequencies at 4, 8, 13, 17, and 22 mc, with frequencies, location, and permitted power input indicated.[49] The largest power input authorized is 20 kilowatts; the smallest listed is 100 watts. Since the coast station is tied in with the telephone system of the region or country in which it is located, it is possible—provided propagation conditions are favorable—for a passenger at sea to converse directly with a person at an inland point halfway around the world.

In late 1957 some seven hundred vessels had radiotelephone equipment capable of maintaining contact with shore stations. Forty-five of these vessels were commercial passenger liners, the bulk of radiotelephone traffic being with ships of this type. For example, the S.S. *United States* alone put through some 3700 calls in 1956, while in the same year the American Telephone and Telegraph Company handled nearly 36,000, most of them from passenger ships.[50]

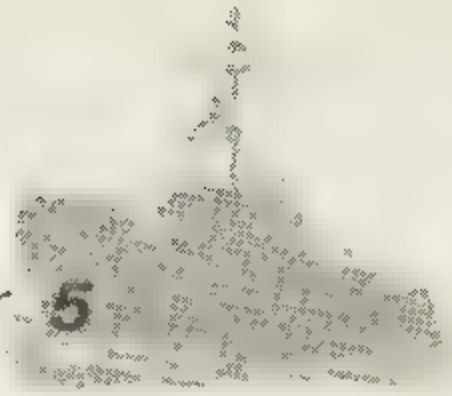
5. *Monitoring: Patrolling the Highways of the Sky*

As a hedge against human fallibility and a check on conscious or unconscious violations of the rules of the radio highways, a system of international monitoring has evolved that enlists the cooperation of administrations as well as of recognized "public or private enterprise."[51] States adhering to the Radio Regulations—Geneva, 1959—agree to support the development of monitoring facilities in order to further the implementation of the Regulations, and to submit reports of their monitoring to other administrations and to the International Frequency Registration Board (IFRB).[52] The Board periodically prepares and submits summaries of monitoring data to the Secretary General of the ITU for his publication.[53] The monitoring stations cooperating with the IFRB conduct spectrum occupancy surveys and carry out measurements on frequencies, field strength, direction-finding, bandwidth, and other characteristics.[54] Violations of the rules appear in large numbers in the monitoring reports, the Federal Communications Commission field engineering statistics for 1962 showing a total of 1904 violation

notices to ship stations alone.[55] The occupancy surveys enable the IFRB to ascertain what registered frequencies are in regular use, or which may be used little or not at all. Over-registration has been a common practice, with administrations staking out claims to frequencies for possible future use and needlessly cluttering up the Master Frequency Register in the process. Under the older Berne registration system (up to 1939), for example, the Soviet Union had registered frequencies at every five or ten kilocycles throughout the radio spectrum.[56]

As is already evident, the ITU does not own and operate its own monitoring facilities but has to rely on the various administrations for such services. Some twenty-six administrations, including the United States, perform these functions, furnishing information to the IFRB for its monthly summaries. These are concerned particularly with the frequencies 2850-27,500 kc, the high frequency bands. The monitoring operations of the United States supply about one-quarter of the monitoring data submitted to the IFRB. The eighteen stations of the FCC, plus sixteen privately operated ones, forwarded 65,000 monitoring observations to the IFRB during fiscal 1962.[57] Cases in which a United States station (non-military) is reported as causing interference to a foreign station or service, and vice versa, are handled directly by the FCC through correspondence, with a satisfactory adjustment usually reached. Cases of interference by a United States military station are turned over by the Commission directly to the branch of the service concerned.[58]

The changing picture of maritime radio communications during the last sixty years has been almost incredible in the improved efficiency and increasing complexity of the techniques involved. Along with technological advance have come increasingly insistent demands by a variety of services for space in the radio spectrum. The attempts to meet these demands and to formulate rules and regulations in connection therewith have heavily engaged the efforts of the international community through the International Telecommunication Union (ITU). While politics have by no means been absent from these deliberations, it has at the same time been realized that the exercise of unbridled sovereignty in radio operations might well deprive even the most chauvinistic of the effective use of this valuable medium of communication. In this process of change, of give-and-take, and of technological transformation, the maritime service has fared reasonably well, and has evolved an amazingly effective series of techniques for meeting the needs of safety of life at sea—radio furnishing the vital links in the process.



Chapter 5 Safety of Life at Sea: Part I

Recognition of its Urgency

SAFETY OF LIFE at sea has been the prime incentive to devise, perfect and secure international agreement on the use of early wireless and modern radio. Prescribing frequencies for international distress use has, therefore, been relatively uncontested, and any trespassing by other services on these guarded wave lengths has usually been inadvertent rather than deliberate.[1]

At general radio conferences as well as at conferences on safety of life at sea, communications problems have received increasingly earnest attention. Provisions for the use of radio in various categories of ships and survival craft and the universally accepted rules applying to it have become more explicit and detailed at each successive conference. These considerations have been at the heart of maritime communications since the first wireless set was placed aboard a seagoing vessel.

International Action on Safety of Life at Sea: The Conferences of 1914 and 1929

The first conference on safety of life at sea, held at London in 1914, has been treated earlier in this study. Since there existed no international organization to exercise continued scrutiny over maritime safety matters, meetings were held on an *ad hoc* basis, and fifteen years elapsed after 1914 before another conference was held. As the London Conference had been influenced by the *Titanic* disaster, so the conference of 1929 met under the shadow of the *Vestris* tragedy. Although in the latter instance casualties were fewer,[2] the loss of life was equally needless.

Carrying an American certificate of seaworthiness for passenger vessels, the *Vestris* had sailed from Hoboken on Saturday, November 10, 1928, for Barbados and South America. She was overloaded, some 200 tons of cargo having been added after the winter deep load line was reached. Off Sandy Hook she developed a list of three to five

degrees which, under severe storm conditions, increased by five o'clock Monday morning to twenty degrees. However, when the Navy radio operator at the Bethany Beach (Delaware) radio compass station, noting that the ship was making little headway, queried her on 500 kc, he was told that no help was needed. The *Vestris* by this time was in dire straits and had virtually lost her steering capacity, but not until 9:56 Monday morning when she was clearly sinking did she send an SOS. The call was answered at once by the Tuckerton coastal station and was logged by fifty-six ships, but too late to save the 110 persons who perished as the doomed ship went down.[3] Presumably salvage implications were responsible for Captain Carey's delay in authorizing the distress call, for there was no defect in the radio equipment of the *Vestris.* It simply was not used soon enough in the type of crisis for which it was installed.

Ironically the *Vestris,* like the *Titanic,* had a deaf ship (SS *Montoso*) nearby which, not equipped with radio, had continued on its course.[4] Profiting from outdated American maritime radio legislation, the vessel had not installed radio equipment.

This lamentable deficiency in communications, which undoubtedly contributed to the loss of life in the sinking of the *Vestris,* gave added urgency to the deliberations of the London Conference of 1929. Substantial gains for safety of life at sea were achieved, but in several instances their full implementation was impaired by exceptions and exemptions. The ideal had to be compromised in terms of what was realizable as concern for safety of life at sea yielded at times to what ship owners felt were the inexorable demands of operating costs. The protest that the costs of safety were too high runs through the entire history of maritime communications (as well as of ship construction)—a manifestation equally evident in other fields such as railroading, mining, and manufacturing. Safety must be legislated: rarely is it willingly embraced by those who bear its costs.

The new radiotelegraph provisions in the Convention and Regulations applied to cargo ships over 1600 tons gross and to all passenger ships (i.e., carrying more than twelve persons). Administrations were authorized, however, to delay for a period of five years the application of these provisions to cargo ships under 2000 tons.[5] Further exceptions to the radiotelegraph provisions stated that passenger ships which did not go more than twenty miles from the nearest land or more than two hundred miles in the open sea between ports might be exempted by each administration. Cargo ships that did not go more than one hundred and fifty miles from the nearest land might also be exempted.[6]

Watches were specified as continuous for passenger ships over 3000

tons, and likewise continuous for cargo ships over 5500 tons. Several cargo ship exceptions were noted that administrations might apply for a period of one year after the coming into effect of the Convention.[7]

The technical provisions of the Convention, largely of antiquarian interest, may be summarized briefly. The 100-mile range of the main transmitter was reaffirmed, an emergency installation was required, and both were to have ". . . a note frequency of at least 100." The receiver was "assumed to be one employing a rectifier of the crystal type without amplification,"[8] thus enshrining still further in the hall of outmoded techniques a device dear only to the hearts of shipping interests reluctant to purchase more modern equipment. There were additional provisions dealing with danger messages, meteorological in-information, distress messages, and direction-finding apparatus.[9]

Ratification by individual countries was slow. The United States Senate, moving with glacial speed, did not ratify until 1936, attaching three reservations as it did so.[10] The United States had, in fact, never ratified the Convention of 1914. Nor was the international climate of the 1930's conducive to calm deliberation on matters requiring amity for their implementation. The growing truculence of the Rome-Berlin-Tokyo Axis drew the attention of nations toward national defense rather than toward safety of life at sea. The *Morro Castle* disaster (1934) was shocking, yet no international conference was held while the memory was fresh in men's minds To be sure, the question of highly inflammable passenger ships was to receive continuing consideration; but no legislation could easily be framed to exorcize human negligence and incompetence on ships at sea, even though in the burning of the *Morro Castle* the acts of the chief radio operator were suspect and the gross incompetence of the chief officer appallingly evident.[11]

IMCO and the 1948 Conference

It had long been realized that the *ad hoc* nature of previous conferences on safety of life at sea, with the long lapse between meetings, fell far short of satisfying the needs of the international shipping community. Revision of the 1929 Convention was long overdue, and awareness of this led the Shipping Committee of the State Department to recommend to the Secretary in 1943 the convening of a conference to consider the problem as soon as feasible after the conclusion of the war. Concern here was not solely with the revision of the existing Convention, but as well with the need to set up the international machinery to provide continuity for the consideration of maritime safety problems.

Conversations with the United Kingdom resulted in an agreement, also in 1943, that she would summon a conference, under the terms of the 1929 Convention, after the close of the war. In November 1946, invitations went out from London to the signatories of the 1929 Convention, with the convening date subsequently agreed upon as April 23, 1948.

Meanwhile the United Nations had been considering the advisability of setting up a specialized agency to ponder the needs of international shipping. The fruit of this contemplation appeared in a recommendation to the United Nations by the Transport and Communication Commission of the Economic and Social Council that it sponsor the setting up of an international maritime agency. There followed the United Nations Maritime Conference held at Geneva from February 19 to March 6, 1948, at which there was drawn up a draft convention for the Intergovernmental Maritime Consultative Organization (IMCO). This conference urged the Safety of Life at Sea Conference, which was scheduled to convene the following month, to consider the possibility that IMCO would come into being at an early date.[12] There was an element of optimism here, for ten years were to pass before enough ratifications were secured to perfect its institutionalizing. As a hedge against possible delay, the 1948 Convention on Safety of Life at Sea provided that until the IMCO Convention entered into force, the government of the United Kingdom should act on an interim basis as a depository for IMCO documents. It was to receive proposals for amendments to the Convention, and to call a conference for the revision of the Convention on Safety of Life at Sea after five years if requested to do so by one-third of the contracting parties.[13] This is but one instance of the close intergration of IMCO and the 1948 Convention on Safety of Life at Sea. Others will be cited later in this chapter.

The structure and functions of IMCO may be briefly noted before proceeding to the more relevant provisions of the 1948 Convention on Safety of Life at Sea. Essentially the structure of IMCO is similar to that of the United Nations and the various specialized agencies in that it consists of a Secretariat, Assembly, and Council, plus a Maritime Safety Committee—the latter an administrative unit peculiar to IMCO.[14]

The Secretariat consists of a Secretary-General, the Secretary of the Maritime Safety Committee, and such additional members as may be deemed necessary by the Secretary-General. The latter is the chief administrative officer of the Organization, and is appointed by the Council.[15]

The Assembly is made up of all the members and meets biennially. Extraordinary meetings may be called, however, if deemed necessary by the Council.[16]

The Council comprises sixteen members, six from nations with the largest interest in international shipping; six from other nations with the largest interest in seaborne trade; and four elected by the Assembly from among nations having a "substantial" interest in international shipping and seaborne trade. The chairman may call a meeting of the Council on one month's notice and at such place as may be convenient.[17]

The Maritime Safety Committee is a body of fourteen elected by the Assembly from the member governments having an important interest in maritime safety. Of these fourteen, at least eight must be chosen from the largest ship-owning nations. The members serve for a four-year term and may be re-elected. They elect their own officers annually, and while annual meetings are specified, the Committee may meet at any time at the request of five members.[18]

The duties of the Committee are to weigh matters concerned with aids to navigation, construction of vessels, collision prevention, the handling of dangerous cargoes, hydrographic information, salvage and rescue. It also maintains liaison with other agencies to aid coordination "in the fields of shipping, aviation, telecommunications and meteorology with respect to safety and rescue." It is required to submit to the Assembly, through the Council, any proposed safety regulations or amendments to existing regulations advanced by members, with its recommendations.[19]

More broadly, in defining the competence of the Organization as a whole, the Convention states that it may make recommendations on matters coming before it as noted in the Convention, or by any specialized agency of the United Nations; it may provide for the drafting of conventions or other agreements; it may convene conferences as necessary; and it may provide the machinery of consultation.[20]

In the latter connection IMCO stands to systematize the already existing interdependence of organizations concerned with safety of life at sea: for example, the World Meteorological Organization, the International Telecommunication Union, and the International Civil Aviation Organization. It is closely concerned, as well, with the functions of the Ocean Weather Ships and the Ocean Station Vessels, which not only provide a flow of essential meteorological information but perform search and rescue services to planes and ships in distress.

In its role as a coordinating and administrative agency in matters

of safety of life at sea, IMCO has fallen heir to the responsibility for a growing number of areas, some of which for many years have been the subject of separate international conventions. Among these are oil pollution at sea, load lines, the international code of signals, tonnage measurements, and collisions in the English Channel. The bringing of these instruments and problems under the purview of a single, permanent international maritime organization represents an encouraging step forward in perfecting the machinery of international cooperation in this significant field.

A recent instance illustrates the initiative that IMCO may exercise in an important matter of maritime safety. Some fifty-three collisions having occurred in the Dover Strait in a twenty-one month period, IMCO requested an investigation by the British Institute of Navigation. Questionnaires were then mailed to shipmasters requesting opinions on the desirability of establishing specific sea lanes in this busy area used by an average of 750 vessels a day. Of the 3512 forms returned, 94 per cent were affirmative and supported the general recommendation made by the Maritime Safety Committee of IMCO on setting up lanes for traffic moving in opposite directions.[21] Since the use of an international waterway was involved, the representatives of the maritime nations were scheduled to meet in the spring of 1964 to consider rules to prevent collisions in this highly congested area.

A similar problem exists on the sea approaches of the Port of New York, where the United States Government has long urged the general acceptance of sea lanes (tracks) to which vessels of United States registry are required to conform. The *Stockholm* would not have collided with the *Andrea Doria* had the former not been twenty miles north of the designated east-bound track. Savings in fuel costs and the keeping of tight schedules become highly irrelevant when set off against the added danger to life and property that may be involved in such a disaster.

As stated, there were two major maritime conferences in the spring of 1948—that which drew up the convention for IMCO, and the Safety of Life at Sea Conference that convened shortly thereafter (the third in the series). Relevant at this point are the radio provisions of the latter.

The 1948 London Conference on Safety of Life at Sea framed more comprehensive radio provisions and included wider categories of vessels than either of the previous conferences. Following the precedent set earlier, the radio regulations were couched in terms of the most recent general telecommunication conference, Atlantic City (1947) in this instance.

The 1948 Convention abrogates the Convention of 1929. It contains a series of appendices, with Appendix 2, Chapter IV, entitled "Radiotelegraphy and Radiotelephony."[22] Although delay clauses and permissible exemptions (too numerous for treatment here) tended to water down the world-wide acceptance of many desirable provisions,[23] tangible gains resulted.

All passenger and all cargo ships over 1600 tons were required to carry radiotelegraph transmitters with a range of 150 miles, and watches were to be continuous unless the vessel was fitted with an auto alarm. At least one qualified operator was specified and the hours of listening were prescribed. The emergency transmitter was required to have a range of 100 miles, with spark sets permitted for this purpose.

Radio direction finding equipment operating on the medium frequencies was specified for all ships over 1600 tons. This apparatus would serve a dual purpose. it would enable a vessel hearing a distress call to secure a bearing on the endangered ship and so plot an accurate course more effectively; and it would enable an RDF equipped vessel to secure bearings, for navigational purposes, from the many radio compass stations throughout the world.

Survival craft radio was stepped up considerably in requiring radiotelegraph equipment for Class A motor lifeboats, while portable radio sets were to be available if a ship carried less than twenty lifeboats.

For the first time radiotelephone equipment was specified for seagoing ships. Cargo vessels of 500-1600 tons were required to carry radiotelephone sets with a range of 150 miles (in the two megacycle band, with the distress frequency at 2182 kc). Watches could be stood by any crewmember holding a radiotelephone certificate, and watch hours were to be specified by each administration. This gave a limited radio capability to cargo ships that had not been covered hitherto in that aid could be summoned quickly; but the possibility of not being heard was far greater than in the use of radiotelegraph on 500 kc. There was, at that time, no automatic call alarm for radiotelephone such as had long been in use with radiotelegraph systems. This left a gap inadequately filled by intermittent listening, one to which national governments and international radio conferences turned their earnest attention in the years that followed.

The close interrelationship between SOLAS 48 and IMCO is nowhere better illustrated than in the SOLAS Convention. It has already been remarked that the coming into force of IMCO was delayed until 1958,[24] with the British Government performing caretaker functions until that date. It might be further noted that signatories of the SOLAS Convention were instructed to submit their compliance reports to

IMCO, along with any special rules agreed upon by the contracting parties. A government refusing to accept an important amendment would, twelve months after such amendment entered into force, "cease to be a party to the Convention."[25] While this contingency has not yet arisen, it could involve disturbing consequences for the vessels of such a dissenting government in their visits to ports of governments accepting the amendment in question.[26]

The Conference of 1960

Upon the invitation of IMCO, the convening organization, the most recent Conference on Safety of Life at Sea (the fourth of the series) opened in London on the 17th of May, 1960. The Convention and Final Act, signed June 17th, abrogated SOLAS 48. SOLAS 60, not yet in force, was to become effective after acceptance by fifteen countries, including seven of those having at least one million gross tons of shipping.[27] Once more, a maritime disaster—the collision of the *Andrea Doria* and the *Stockholm*—was an impelling force in driving the conference to devise more adequate rules to insure greater safety of life at sea.

In a number of significant instances the 1960 treaty went beyond that of 1948 in its radio provisions.[28] In those that follow, the Great Lakes and their tributary waters are excepted, communications agreements in this area being handled on a bilateral basis by the United States and Canada—in terms, of course, of the current ITU regulations.

The safety provisions relating to radio are in many respects similar to those of the 1948 treaty, but at the same time several significant advances are apparent.[29] It should also be kept in mind that these regulations are dotted with delay clauses and exemptions permitted to the contracting governments.[30]

As previously, all passenger ships are required to carry radiotelegraph with a range of 150 miles for the main transmitter and 100 miles for the emergency station.[31] An automatic radiotelegraph keying device is required for distress use for both the main and the emergency transmitters. The latter goes beyond the 1959 Geneva regulations and insures more effective actuating of the auto alarm on other vessels. The auto alarm specifications are tightened up in the assertion that it must be sensitive enough to be actuated by the distress signal from a survival craft, a ship's emergency station, or a coastal station, but not by atmospherics or any other radio signals.

Watches are specified as continuous (by qualified operators) unless the ship's station is fitted with an auto alarm, and the hours of listen-

ing are to be determined by the number of passengers carried. Radio direction finders are required for all ships over 1600 tons, and radar is recommended as a navigational device.[32] Motor lifeboats are required to carry radiotelegraph capable of both manual and automatic keying, and to have a range of at least twenty-five miles on the frequencies 4000-27,500 kc Portable radio gear must be available for lifeboat use if two motor lifeboats, equipped as described, are not carried.[33]

The requirements for cargo ships are more elaborate than previously, with the minimum tonnage for which radio is specified lowered from 500 to 300, and with added prescriptions for radiotelephone installations. For cargo ships over 1600 tons the radiotelegraph requirements are the same as those for passenger ships. For cargo ships under 1600 tons radiotelegraph is required with a range of 100 miles for the main transmitter and 75 miles for the emergency station. Or, as an alternative, ships under 1600 tons may carry radiotelephone with a range of 150 miles for those between 500 and 1600 tons, and 75 miles for those between 300 and 500 tons. For those ships of 500-1600 tons, the watch receiver must be pre-set on the distress frequency of 2182 kc, and must in addition be equipped to transmit the automatic radiotelephone distress signal—an alternating two-tone signal previously described.[34] Furthermore, a continuous watch must be maintained by a qualified radiotelephone operator, or by a loudspeaker on the bridge. By thus enlarging the category of cargo vessels in which radio must be carried, and by adding the requirements of the automatic distress signal as well as continuous listening for radiotelephone stations, some of the ambiguities inherent in SOLAS 48 regulations have been minimized.

As one looks back briefly over the past half century during which the international maritime community has searched for more effective ways to insure the safety of life at sea, many striking gains are evident. Improved radio techniques and broadened categories of vessels affected have greatly reduced the possibility of a deaf ship within rescue distance of a maritime disaster. For a variety of reasons already noted, the advances and improvements in maritime radio communications have at times been frustratingly slow in implementation. At the same time, the accomplishments of the four SOLAS conferences and the general radio conferences have been very substantial. The initial use of primitive wireless was in the interest of safety of life at sea, and the vastly improved techniques of modern radio are directed toward the same end. The constantly widening applications of radio in this respect are further illustrated in the sections and chapters that follow.

The International Ice Patrol

One of the first measures by which the international maritime community undertook to provide safeguards against a serious menace to safety of life at sea, and second in point of time only to the adoption of wireless by the maritime service, was the International Ice Patrol.

Begun informally by the United States shortly after the sinking of the *Titanic*, when two naval vessels were sent to patrol the area off the Grand Banks, the Ice Patrol became institutionalized on an international basis at the London Conference for Safety of Life at Sea in 1914, with the United States as the prime managing power. Except for the periods of the two world wars, the Patrol has continued to the present time.

Starting in late February or early March, when the calving of bergs by the Greenland glaciers institutes an actual or potential threat to the North Atlantic sea lanes, the Patrol continues until July or August. The duration and severity of the ice season vary according to the amount and southward drift of the ice, the latter being determined by currents and wind conditions. The persistence of strong northwesterly winds along the Labrador coast in late winter gives the floating ice greater cruising range and can well mean a severe season for both the Ice Patrol and the vessels sailing the tracks of the North Atlantic. The year 1957 was especially bad, with the northerly summer route unusable. In this case Coast Guard vessels had to ride herd on the large bergs below the Grand Banks, continuing the patrol until August, a month longer than usual. The 1963 season, by contrast, was very light and patrol vessels were not needed. Periodic flights by long range aircraft provided the observations necessary to keep shipping adequately warned on ice conditions. As of mid-April 1964, the patrol notified shipping that the middle track was endangered by a ninety-mile stretch of bergs where "a serious threat exists," thus necessitating continued use of the southerly route.[35]

The United States Coast Guard was assigned to ice patrol duties off Newfoundland a year before the first London Safety of Life at Sea Conference met, the cutters *Seneca* and *Miami* patrolling the area in 1913.[36] This function is still performed by the Coast Guard today, the costs being underwritten by the countries signatory to the existing convention.[37] Each country's contribution is determined by the total gross tonnage of its ships using the North Atlantic sea lanes thus protected.

"It is the proper use of modern radio that makes it possible to operate an effective patrol."[38] The twice daily ice broadcasts to ships from Radio Argentia are based on the gathering and evaluation of data from a variety of sources, all communicating by radio. The aerial

observations carried out by the Coast Guard from its Argentia base (and the use of surface patrols if necessary), information radioed by other aircraft traversing the area, and reports from surface vessels provide the basic information from which the radio reports to ships are compiled. Reports requested every four hours from surface vessels comprise data on sea temperature, weather conditions, visibility, ice sighted, and wind, the latter being particularly important in determining the drift and set of ice as well as being a partial basis for weather forecasts.[39] Reports from surface vessels are particularly significant in rounding out the general picture of ice hazards when weather conditions prevent reconnaissance by Coast Guard aircraft.

The Argentia broadcasts (there are also broadcasts twice daily from Naval NSS at Washington, based on ice information furnished by the Commander, International Ice Patrol) begin with CQ on 500 kc, instructing listening ships to shift to 155, 5320, or 8502 kc for reception of the ice bulletin to follow. These are CW broadcasts, first at 15, and then repeated at 25 words per minute. Unusually hazardous conditions occasion a special broadcast preceded by the international safety signal TTT.[40]

Oceanographic research has been added to the duties of the Argentia-based Coast Guard, the *Evergreen* carrying special equipment and personnel for this purpose. It is hoped that the data thus secured will facilitate the forecasting of ice conditions for the subsequent season.[4]

For ships equipped to receive this type of transmission, daily facsimile broadcasts from Radio Argentia (on 5320 and 8502 kc) provide a valuable picture of sea conditions in the area. The aircraft and surface vessels of the Ice Patrol are also available for search and rescue missions as needed.[42]

The complex operations of the International Ice Patrol, integrated and brought to a focus by modern radio, are a far cry from the chaotic conditions of 1912. The *Titanic's* experience—proceeding at better than twenty knots in an ice field about which several wireless warnings had been received from other ships—seems now a nightmare out of the remote past. The international law of the sea, as embodied in the conventions on safety of life at sea, enjoins shipmasters to exercise the greatest caution when navigating in the vicinity of ice; and periodic warnings by radio provide full information for their guidance. Ice in the northwestern Atlantic still claims an occasional victim as in the case of the *Hans Hedtoft*, which, with all hands, sank January 31, 1959, off the southern tip of Greenland For the most part, however, such losses are as rare as the warnings are numerous—thanks largely to the effective work of the International Ice Patrol.

Chapter 6 Safety of Life at Sea: Part II

Radio in Search and Rescue

THE USE OF radio in contact at sea has clearly become more elaborate as improved techniques have broadened its scope and efficiency. The nature of this development can be seen in the preceding chapters, in the constantly expanding prescriptions of safety of life at sea conferences, and in the attention given to maritime safety at the world-wide and regional telecommunication conferences. The operations of the International Ice Patrol constitute one phase of this evolving process, and other instances will be examined in the pages that follow.

The world-wide procedures by which a ship at sea may make known is distress have been reviewed,[1] but additional considerations may be briefly noted. The station (ship or aircraft) in distress is responsible for the control of radio traffic relating to its emergency unless this responsibility is delegated to another station.[2] For the emergency may be so dire, or the radio capability of the endangered craft so limited that such delegation of control is necessary. If, on the other hand, a ship is so overwhelmed that it can get off only a brief distress call, it is incumbent on another vessel to assume responsibility for informing shore stations and other vessels and to take over traffic control so that SAR (Search and Rescue) machinery may be set in motion. All ships hearing a distress call are obliged, by the treaty law of the sea, to respond and to proceed as expeditiously as possible to the distress scene. An answering ship may be released only if the master of the distressed vessel informs it that its assistance is not needed, or if it learns that other ships have been requisitioned and are complying.[3] Such a situation developing in the Atlantic would probably find AMVER[4] (Atlantic Merchant Vessel Reports) an active participant in pinpointing the location of vessels best situated and

equipped to engage in the rescue process. A distress call on one of the busy Atlantic sea lanes might be logged by fifty or more ships, and it would be needless for all to head at top speed toward the disaster. A selection process is therefore necessary in which the nearest and most capable vessel or vessels can be directed to the distressed craft.

The radio call thus initiating the SAR process would, in most cases, be on 500 kc, the traditional world-wide distress frequency designated for the maritime service.[5] Much of the radio traffic attendant upon the SAR mission would be shifted to other working frequencies (some of which will shortly be noted) in order to reduce interference on the distress frequency. The major current problem in the use of 500 kc lies not so much in the characteristics of the frequency as in the often excessive use to which it is put as a calling and traffic handling channel. Both international and regional conferences have attempted to reach fuller agreement on providing greater protection for the frequency by cutting down on these practices.

Attention has previously been directed to another distress frequency assigned to the mobile service on a world-wide basis—that at 2182 kc, on which voice is the transmission mode. The relatively moderate cost of setting up a station of this type, plus the fact that its operation does not require an operator trained in CW techniques, has made it possible to require such equipment (as an alternative to CW) on ships under 1600 tons. It has also been installed on thousands of small craft and pleasure boats and has been a boon in breaking the wall of silence that formerly enveloped large numbers of craft in the lower tonnage categories. Thus there are two frequencies and two modes of transmission now designated on a world-wide basis for the mobile services.

This dual system has resulted in certain incompatibilities that have yet to be fully reconciled. Ships carrying one mode do not usually carry the other, and capability in both is limited to a few of the larger vessels. Coastal stations may guard both 500 and 2182 kc, and rebroadcast on 500 kc a distress call picked up on 2182. U.S. Coast Guard ship and shore stations commonly have this dual capability, but most merchant vessels do not. This means that while all passenger vessels and cargo ships over 1600 tons guard the 500 kc frequency (the duty operator or the auto alarm), they would not hear a distress call on the 2182 kc voice frequency, nor would most vessels using the latter be able to pick up an SOS on 500 kc. Thus it is quite possible to have a deaf ship situation such as has characterized some earlier marine disasters, where both ships are equipped with radio but operate

on different frequencies. This situation would in part be ameliorated if the smaller vessels which are required to carry radiotelephone equipment could also be induced to have available the survival craft type of gear with which they could broadcast their distress on 500 and 8364 kc as well as on 2182. The large number of ship and shore stations guarding these CW frequencies would insure a response and the initiation of SAR procedures, but such a vessel still could not hear a distress call from another ship using the 500 kc frequency. A partial answer to such a situation lies in a coastal station's rebroadcasting on 2182 a distress call that it has intercepted (presumably on either 500 or 2182 kc).[6]

The gap of incompatability between the two frequencies and transmission modes has been narrowed but is far from being eliminated. The picture is further clouded by the frequent abuse of the 2182 frequency by boat owners who use it for needless transmissions, such as requests for a communications check, ignoring the fact that their transmitters, in all likelihood, have three other working frequencies (2670, 2638, and 2738 kc), any one of which could be employed without cluttering up the one reserved for distress. Interference can be much more serious on voice than on CW, resulting in the complete obliteration of a distress call by a stronger signal.

One further comment on the world-wide use of the 2182 kc voice frequency needs to be made. The ships employing this mode of transmission represent many nationalities and languages, and constitute a problem in intercommunication that could be severe or even tragic. In CW this barrier has largely been surmounted by the system of "Q" signals in world-wide use. There is no comparable method applicable to radiotelephone. The 1960 Conference on Safety of Life at Sea, recognizing the seriousness of the problem, urged that studies be undertaken to develop an international radiotelephone code as recommended by the Geneva Conference of 1959, specifying that it should be both short and simple in order to serve the purposes of safety of life at sea.[7]

Turning to the broader aspects of SAR, we find that most countries fronting on the great oceans and seas of the world have some rescue facilities at hand, such means ranging from a few lifeboats to the elaborate semi-global structure created and coordinated by the U.S. Coast Guard. Participating in this far-flung enterprise are ICAO and the national governments of Canada, Mexico, and several countries of northern and western Europe—including, of course, Great Britain.

The National Search and Rescue Plan[8] of the United States embraces the Western Atlantic from the tip of Greenland to the Guianas in

South America, including the Gulf and Caribbean regions. In the Atlantic off Canada there is a rough square approximately 1500 miles on a side which represents the Canadian ICAO area and includes Ocean Stations CHARLIE and DELTA. The SAR Plan in the Pacific, roughly north of the equator, includes the waters off Canada and Alaska but not those of the USSR. Japan, in cooperation with the NSRP, is responsible for her own maritime region. A triangle jutting out into the Pacific approximately 1000 miles to the west represents the ICAO area for which Canada exercises responsibility.[9] In the Pacific are two Ocean Stations manned by Coast Guard vessels: NOVEMBER, between Hawaii and San Francisco, and VICTOR, between Midway and Tokyo. The functions of these Ocean Station Vessels in both the Atlantic and Pacific will be more fully elaborated in the following section of this chapter.

The National Search and Rescue Plan (NSRP) achieves much of its efficiency in the full cooperation of neighboring states and of ICAO members. In Canada, for example, where the RCAF coordinates SAR, there can be brought into the rescue process as necessary the Department of Transport, the Royal Canadian Navy, towboat operators, and commercial fishermen.[10] Along the coasts of the United States and on the Great Lakes, the Coast Guard operates 159 lifeboat stations equipped with various types of boats and vehicles suitable for rescue purposes. Continuous watches are maintained as well as beach patrols where necessary. At all these stations immediate action can be taken to safeguard life and property. · In many European coastal countries lifeboat stations of this type are privately supported and manned by volunteers.

Much but not all of the complex NSRP centers on the needs of aircraft in distress; but surface vessels are often involved either as the objects of SAR or as participants in the rescue process. High frequency direction finding (HF DF) nets can be brought into play for SAR purposes in the Western Atlantic and Pacific Oceans. These may be the military nets or the system operated by the FCC, which can be alerted by the appropriate Rescue Coordination Center (RCC) and which can take bearings on any frequency from 1500 to 30,000 kc. Available at air facilities and on some naval vessels are VH DF and UHF DF capable of securing a fix giving an aircraft its position. Ranges are limited at these frequencies, with effective distance determined in large part by the altitude of the aircraft requiring assistance. For a range of 100 miles, for example, aircraft must have an altitude of at least 10,000 feet.[12]

More familiar in maritime practice is the medium frequency direc-

tion finder (MF DF) to which attention has been called at several points in this study. The MF DF is carried by most Coast Guard and merchant vessels and can be used to secure bearings from transmissions on 500 kc. The appropriate RCC can secure bearings on a distressed craft from ship, shore, and aircraft stations; establish a reasonably accurate fix; and initiate the SAR procedure as well as give the distressed craft (especially important in the case of aircraft) its position.[13]

A revealing example of the importance of bearings in a distress case is cited in the Coast Guard's *Aircraft Emergency Procedures Over Water* An amateur yachtsman in Minneapolis, planning a trip down the Mississippi and across the Gulf to Florida, procured with his supplies a surplus Gibson Girl and some flares. All went well until, when he reached the Gulf and was heading for the west coast of Florida, his engine failed. Actuating the Gibson Girl, he was able to transmit a distress signal on both 500 and 8364 kc, alerting stations as far away as Alaska. The Coast Guard station at Richmond, Florida, requested bearings from vessels hearing the SOS. Some 134 were submitted, including nine from aircraft in the area,[14] a discernible tendency toward saturation. The cutter that took the distressed craft in tow had no problem in ascertaining the position of the becalmed yachtsman.

An aircraft in distress off the coast of the United States has one other resource by which it may call attantion to its plight. Flying the emergency radar triangular pattern will alert the shore radar nets to establish a fix,[15] even if the radio of the aircraft is inoperative. It is then possible to alert the SAR units, and particularly ships at sea, that are in a position to give aid in the emergency.

When SAR procudure is invoked, responsibility for over-all direction falls to the Rescue Coordination Center most effectively situated. In the Pacific it might be San Francisco, Hawaii, Guam, or Midway; while in the Atlantic it could be Boston, New York, Norfolk, or Miami; more distant, the appropriate command in Puerto Rico, or the Azores would exercise the functions of SAR. By way of example, the crisis ensuing from the collision off Nantucket of the *Stockholm* and the *Andrea Doria* called into action the New York RCC.

The array of facilities that can be brought to bear in SAR, with radio as the prime medium of communication and coordination, is formidable indeed. These include Coast Guard land, ship, and aero stations; the U.S. Air Force, Navy, Army, Marine Corps, and military DF stations; the FAA radio stations; commercial coastal stations and harbor radio facilities; the FCC DF nets; Canadian commercial

and military stations; maritime mobile ship stations.[16] The semi-global coverage of this system, with its vast resources, goes far beyond the minimal prescriptions of existing treaties and adds immeasurably to the safety of life at sea.

Ocean Station Vessels and Ocean Weather Ships

This twin designation indicates a difference in terminology rather than in function of these ships. The eleven currently on station (nine in the North Atlantic, two in the Pacific) are all weather ships, while those manned by the U.S. Coast Guard are designated Ocean Station Vessels (OSV). Not to be confused with the International Ice Patrol, the weather ships are on station throughout the year on a rotational basis.

Originally tried out during World War II Ocean Weather Ships became institutionally formalized in 1946 in response to the needs of international aviation. The special conference of the Provisional International Civil Aviation Organization (PICAO) in September 1946, agreed to establish thirteen weather stations in the North Atlantic to provide meteorological, navigational, communications, and SAR facilities for the area.[17] On the assumption that airlines of the United States would carry the bulk of transatlantic travel, it was agreed that this country would maintain seven stations and share another with Canada. The others were to be maintained by other interested nations, in some cases jointly, including the United Kingdom, Belgium, the Netherlands, France, Norway, and Sweden. Provision was made for financial contributions by those countries not directly concerned in the maintenance of weather stations.[18] In April 1947, the permanent organization ICAO replaced PICAO, with headquarters in Montreal, Canada.[19] Effective July 1, 1950, and following the ICAO Conference at London in 1949, the number of Atlantic Ocean Stations was reduced to ten,[20] and subsequently to nine, of which the United States now maintains four (BRAVO, CHARLIE, DELTA, ECHO) as well as two in the Pacific (VICTOR and NOVEMBER).

In addition to providing routine services to both air and surface craft, the Ocean Weather Stations have played a dramatic role in SAR, the function with which this study is most directly concerned, and which will be discussed more fully in the pages that follow.

As stated, four of the nine Ocean Weather Stations in the North Atlantic are U.S. Coast Guard manned. Each is centered in a square 210 nautical miles on a side, having a letter designation B (BRAVO), C (CHARLIE), D (DELTA), and E (ECHO). The other five ocean stations likewise have letter designations: A (ALFA), M (MIKE),

J (JULIETT), K (KILO), and I (INDIA). The vessel (OSV) assigned to a specific station assumes these letters for radio communication; and its voice call, while on station, would, for example, be "Ocean Station BRAVO," and its CW call, 4YB.[2] While proceeding to or returning from its station, the vessel uses the four-letter call assigned by the Commandant and as authorized by IRAC.

The radio procedures followed by an OSV call for a high degree of training and versatility on the part of its operating personnel. In CW operations it may have to follow military radiotelegraph procedure, Navy format, ICAO procedure, or the current ITU regulations for the maritime mobile service. On radiotelephone the procedures might be based on military radiotelephone directives, USAF air-ground procedures, or ICAO radiotelephone procedures for contacts with ICAO stations and aircraft.[22]

The meterological functions of an OSV, particularly significant to aircraft, but important as well to surface ships, comprise gathering data—both surface and aloft -on temperature, pressure, wind direction and velocity, cloud types, and visibility. Weather observations of varying types are made and transmitted hourly. As a rule four Weather Bureau personnel are aboard.[23]

These vessels also relay to Weather Observer, Washington, weather observations from merchant vessels that are cooperating with the World Meteorological Organization (WMO).[24]

For furnishing navigational aid to both aircraft and merchant vessels, each OSV is equipped with a radio beacon transmitter, each using a different frequency and a tone-modulated carrier. BRAVO's frequency is 391 kc; CHARLIE's, 385; DELTA's, 350; and ECHO's, 362. The beacon of an on-station OSV is identified, in addition to its frequency, by a four-letter code group, e.g., YBOH for station BRAVO, the last two letters making up the grid designation, which is based on ten-mile squares in the ocean station. En route, OSV's may use a beacon frequency of 410 kc for surface vessels, and 522 kc for aircraft.[25] Its own navigational equipment, LORAN in particular, enables it to determine its position accurately at any time, whether en route or on station, thus giving its beacon virtually the precision of a shore beacon of known position.[26]

Far out to sea, athwart the major shipping as well as air lanes, the OSV is favorably placed to perform important functions for merchant vessels. These functions may comprise merely the routine relaying of weather data or a ship's report to the AMVER center in New York. On the other hand, the radio facilities of the OSV may be invoked for warning or for urgent or distress cases involving

surface ships or aircraft. Since the OSV is available for SAR, it may have to act directly as well as serve as a communications center, in an incident involving safety of life at sea.

In contacts with merchant vessels the most common frequency used is 500 kc, but CW contacts may also be made on the higher frequencies,[27] depending on the radio capability of the ship being called, the distance, and propagation conditions at the time. While a merchant vessel may call an OSV at any time on one of the guarded frequencies and be reasonably sure of an answer, the reverse is not always true. Some 75 per cent of all merchant vessels are one-operator ships with a total of eight hours watch per day—watch hours for which there may be no published schedule. Short of a distress signal that actuates the auto alarm, radio contact with these ships may be very uncertain.

In distress cases where a surface vessel or aircraft may not be able to alert surface vessels in the area, the OSV can broadcast the distress message preceded by the auto alarm as well as take additional steps to initiate SAR on behalf of the distressed craft.[28] An OSV on a SAR mission guards the frequencies between and 2 and 25 mc (including 8364 kc) as well as the 121.5 and 243 mc frequencies. Other frequencies are now used for general communications in SAR operations, e.g., 466 kc, 121.6 mc, 282.8 mc. In keeping Coast Guard Washington (NMH) informed, alternate plans are available for radio relay by other OSV's in case ionospheric disturbances so require.[29]

The OSV is more likely to play a primarily coordinating role in maritime SAR unless the scene of distress is reasonably close to the weather station's position. As a rule one or more merchant ships can be summoned within a fifty-mile radius on the North Atlantic sea lanes so that it would not be necessary for the OSV to leave its station except under the most unusual circumstances. Even so, during the early 1950's the OSV's saved sixty-eight persons from two distressed ships in the Atlantic.[30]

The most specialized function of the OSV is the ditch and rescue procedures for aircraft in distress. To summarize a complex process requiring maximum skill and judgment, the OSV must locate the aircraft, vector it to the ship's position, assist in landing night or day, provide a lighted sea lane and overhead illumination as necessary, and rescue the occupants after ditching.[31] This has occurred several times in the Atlantic, occasionally under the most severe conditions. For sheer dramatic success, however, few instances surpass the ditching of the Pan American *Sovereign of the Skies* in the Pacific the morning of October 16, 1956.[32]

Bound for San Francisco from Honolulu with twenty-four passengers and a crew of seven, Flight 943 was routine until 3 a.m., when number 4 engine went out. Able to feather the propeller, the pilot continued; but when shortly afterward number 1 ran wild, he was forced to an urgent decision. The $1,500,000 Stratocruiser had valuable cargo as well as passengers. She was approximately 1150 miles southwest of San Francisco. It was night, and ditching by day can be perilous. But proceeding with the two overtaxed inboard engines was even more risky. Number 1, uncontrollable, was cutting down air speed and altitude. Although in his twenty-five years of experience Captain Richard Ogg had never been forced to ditch, he now alerted his passengers. Ten miles west, in OS NOVEMBER, was the *Pontchartrain* to which he had reported in passing. He turned back. Keeping in constant communication with the Coast Guard cutter, he dumped his excess fuel, preparing to ditch. Then finding that he could stay aloft, he orbited in eight-mile runs waiting for daylight.

Radio messages passed rapidly between the Stratocruiser, the *Pontchartrain,* the Coast Guard stations at San Francisco and at Honolulu, and the complex network of air-sea rescue operations started to function. All ships within 300 miles went on radio alert; another Pan American clipper and four naval vessels were diverted to the scene.

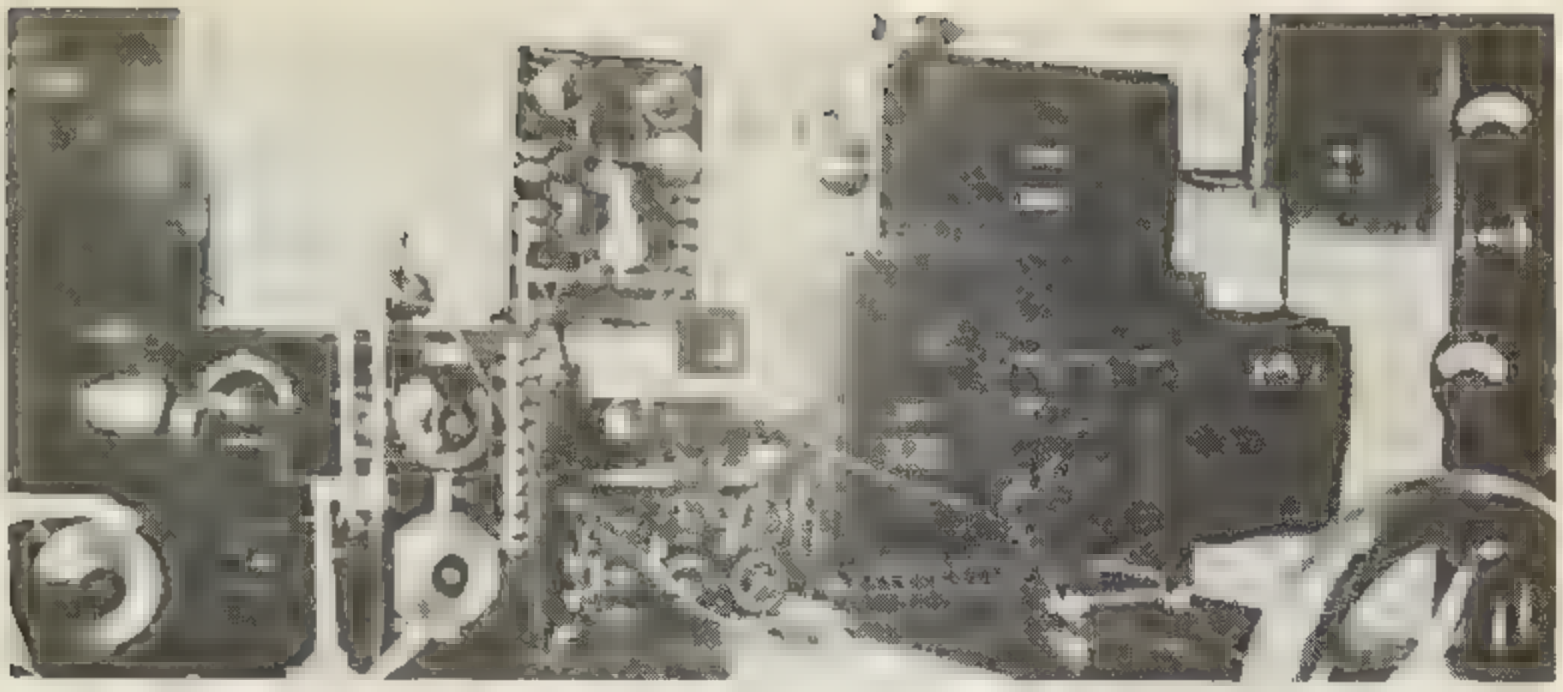
Meanwhile, the *Pontchartrain,* brightly lighted, stood ready, her lifeboats over the side, flares marking a sea lane. With the coming of daylight she laid down a path of fire extinguisher foam to guide the pilot and reduce the risk of surface fire. Five hours after the *Sovereign of the Skies* had been crippled, at 8:16 a.m., she came in for her last landing. As she broke in half and her survivors climbed aboard her rafts, the Coast Guardsmen in motor lifeboats moved in quickly, and within fifteen minutes had picked up all hands from the plane. Although some were wet and frightened, none required medical care, and they completed their trip to San Francisco aboard the *Pontchartrain.*

The rescue was, in one sense, routine. An able and disciplined crew had performed expeditiously and with skill. Yet the saving of lives is always intense human drama, and this incident added one more bright chapter to the story of the U.S. Coast Guard in its dedicated work of furthering safety of life at sea.

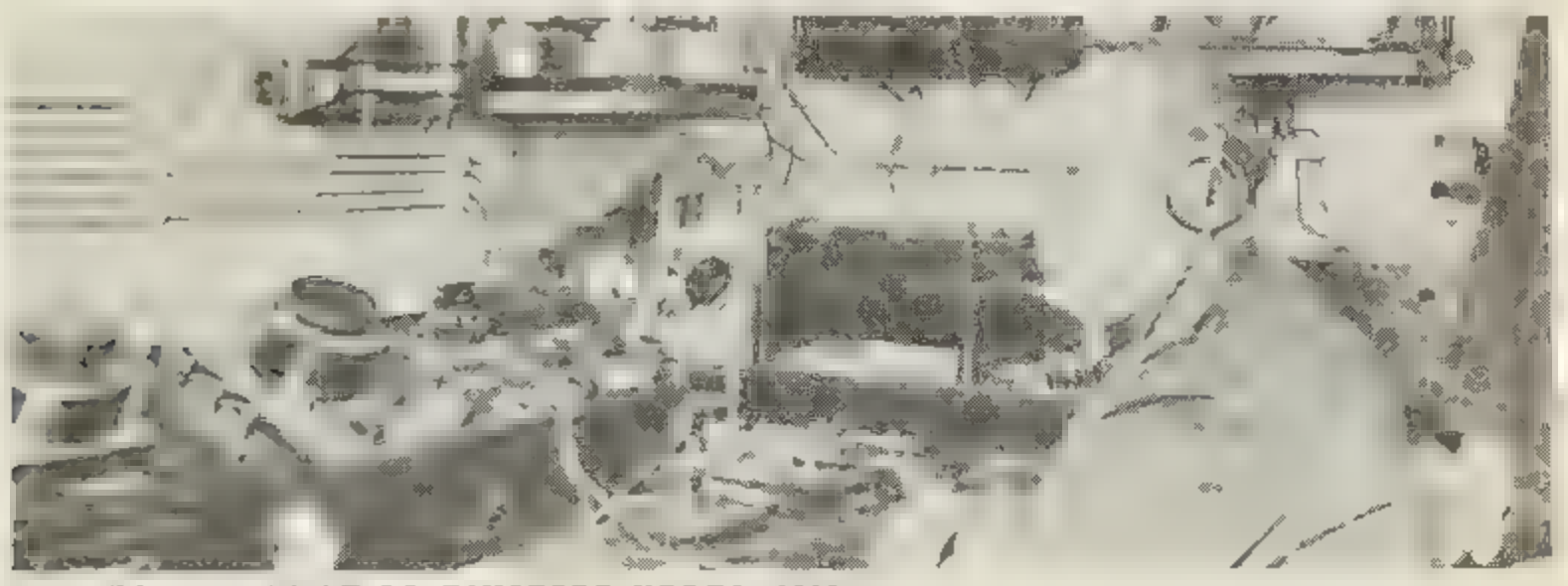
The National Search and Rescue procedure for the Pacific has already been broadly described, but to it should be added Plan ALFA, set up by the Coast Guard Commander Western Area. This plan

provides information on ship positions along the Honolulu-mainland track for the benefit of aircraft flying that route, stressing communication and rescue capabilities, homing procedures, and survivor rescue. Practice drills between ships and planes indicated that communications (voice) on 2182 kc could be successful up to 600 miles, and that a ship's radio direction finding signals on 410 kc (*Matsonia* in one test case) were effective 230 to 530 miles from ship to aircraft.[33] Tests between aircraft and other ships and naval vessels were equally encouraging, indicating that ships with the necessary radio capability could be great potential assets in the SAR plan for the Pacific—supplementing the resources of the two OSV's, which alone could not provide full coverage for so vast an ocean.

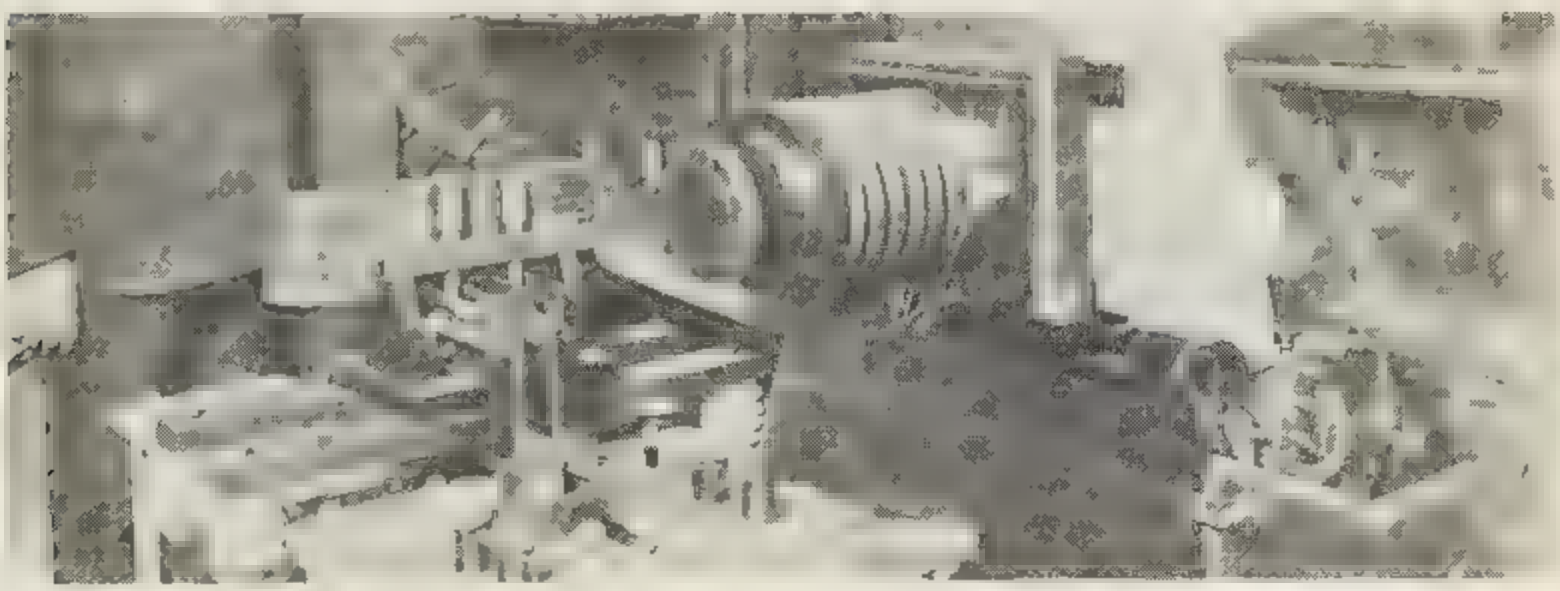
The Atlantic OSV's provide a number of secondary services, of which three deserve particular mention. They perform oceanographic and other scientific observations;[34] they are required to preserve a high state of readiness for anti-submarine warfare (ASW), with SONAR listening watches maintained whenever practicable;[35] OSV's BRAVO and CHARLIE, because of their remote positions, normally carry doctors, enabling them to answer MEDICO's directly, while the French manned OWS carries both a doctor and a nurse.[36]



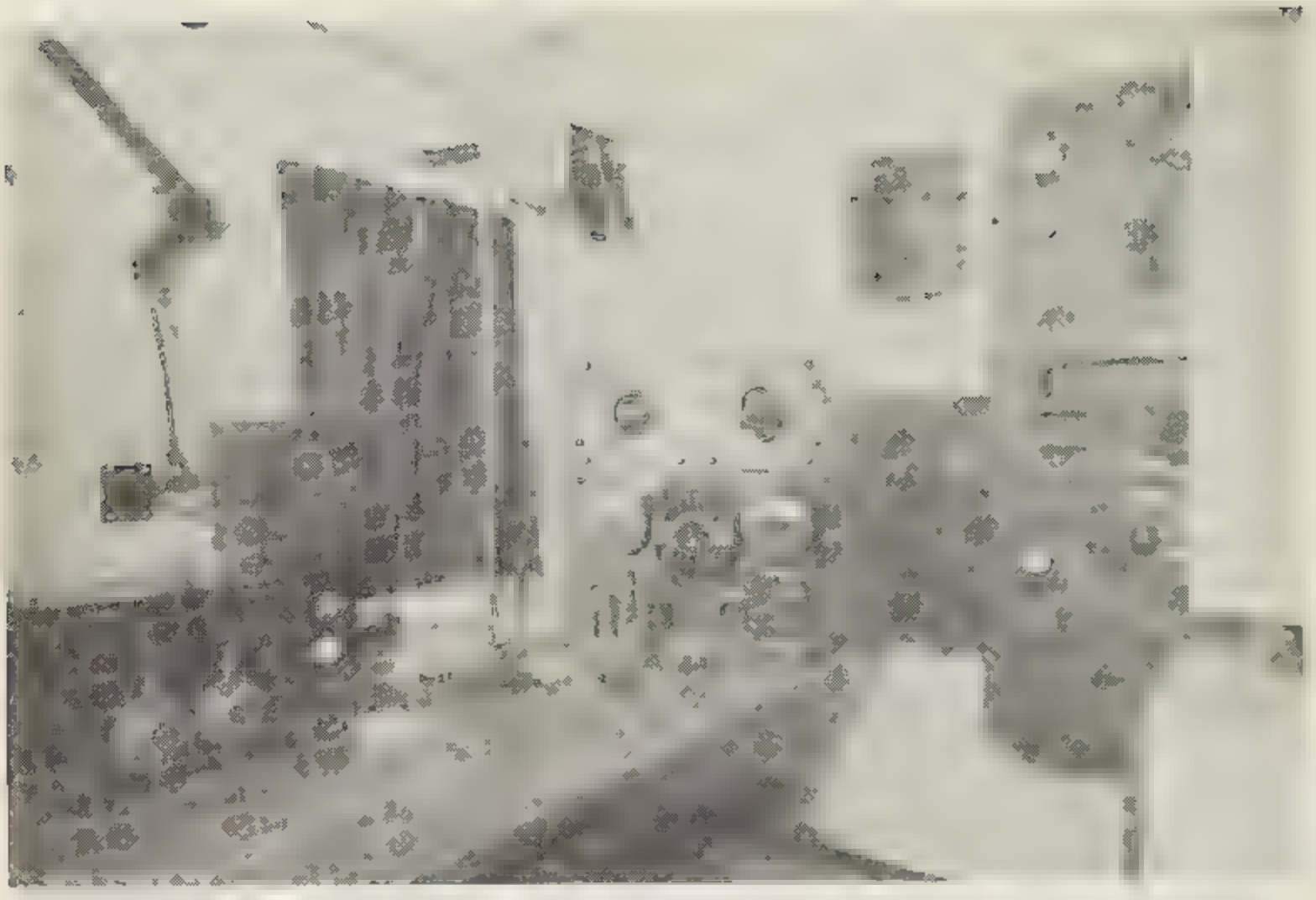
RADIO ROOM OF THE USS *NOKOMIS*
A PRIVATE YACHT (DODGE OWNED) CONVERTED TO A COMMUNICATIONS VESSEL BY THE U S NAVY DURING WORLD WAR I THE USS *NOKOMIS* HAD UNUSUAL RADIO VERSATILITY THE MAIN TRANSMITTER WAS A ONE KW SPARK SET PLUS AN EARLY RADIOTELEPHONE INSTALLATION, WHILE THE NAVY RECEIVERS USED THE DE FOREST AUDION DETECTOR THE ANTENNA SWITCH IN LEFT FOREGROUND IS A MARCONI PRODUCT.
Information and photo courtesy Ed. G. Raser and the W2ZI Historial Wireless Museum.



RADIO ROOM OF SS *GIUSEPPE VERDI* (1919)
OPERATING POSITION OF THE SS *GIUSEPPE VERDI* SHOWS MARCONI RECEIVING GEAR, ANTENNA LOADING COIL, WITH EMERGENCY SPARK COIL AND OPEN GAP AT RIGHT BULBS ABOVE OPERATOR'S HEAD ARE PART OF A POTENTIAL BUT NON-OPERABLE CW TRANSMITTER
Photo courtesy of Emily Ellsworth.



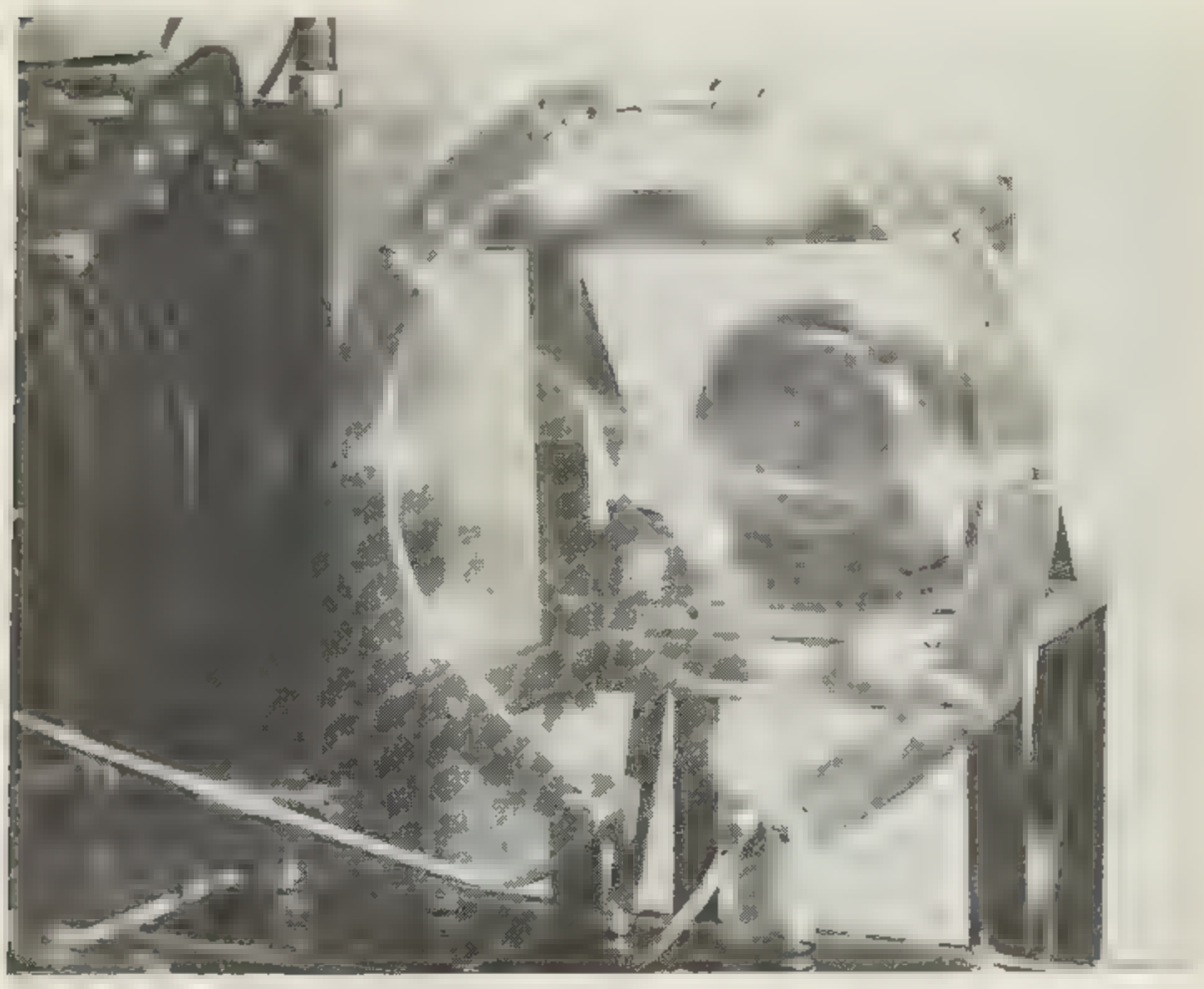
MAIN TRANSMITTING ROOM OF THE SS *GIUSEPPE VERDI*
OF SPECIAL INTEREST IN THIS 2 KW SPARK TRANSMITTER IS THE ROTARY GAP SHOWN AT RIGHT, WITH CONTAINER COVER OPEN. THESE NOISY DEVICES WERE FREQUENTLY HOUSED IN A COMPARTMENT SEPARATE FROM THE OPERATING POSITION, A PRACTICE DICTATED BY MERCY AS WELL AS EFFICIENCY
Photo courtesy of Emily Ellsworth.



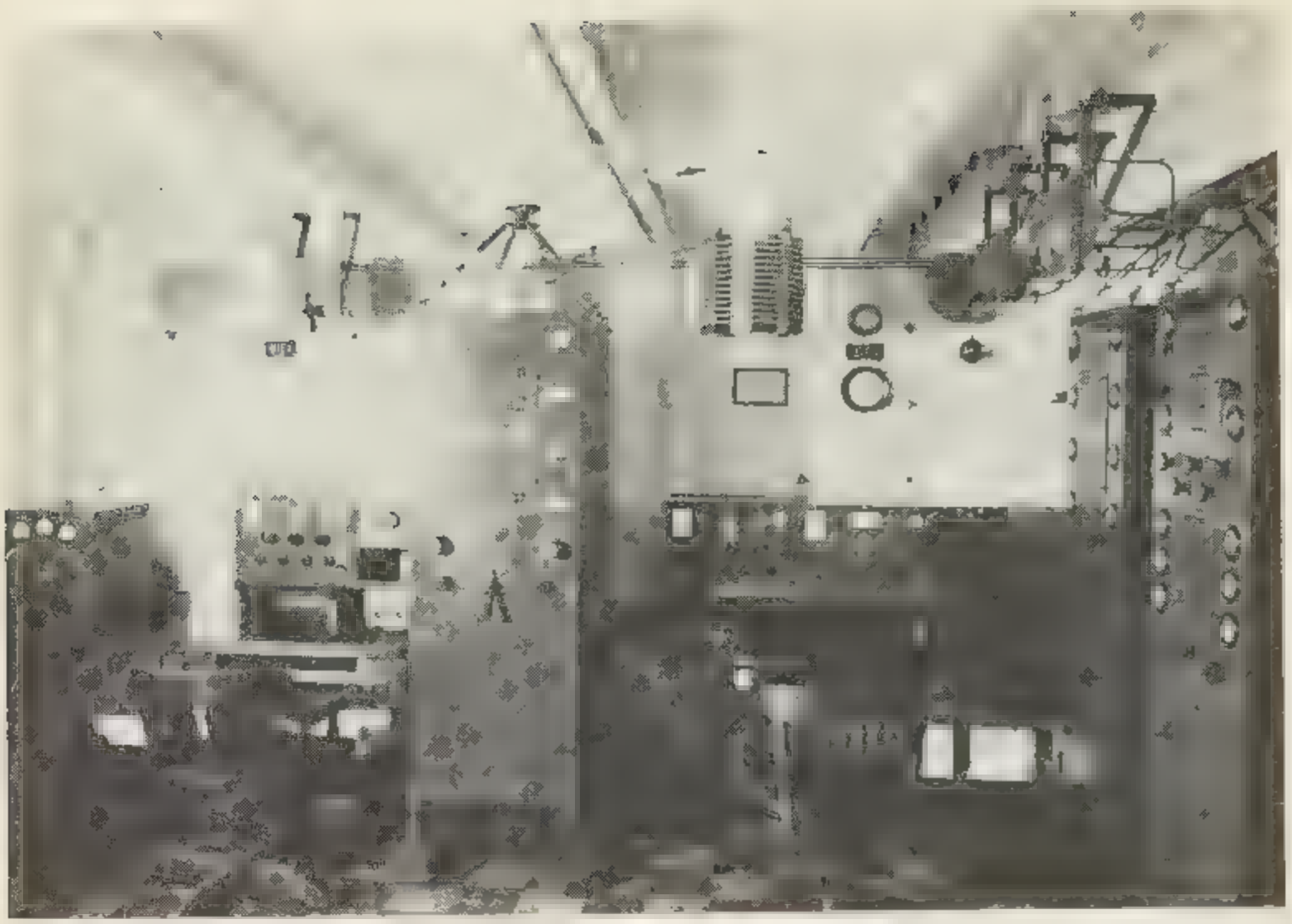
RADIO OPERATING POSITION OF THE SS *AMERICAN LEGION*, 1921 SHOWN ARE THE NAVY RECEIVER WITH AUDION AMPLIFIER AND AT RIGHT, THE BATTERY POWERED AUXILIARY AND EMERGENCY TRANSMITTER. MAIN 2 KW TRANSMITTER NOT SHOWN.
Information and photo courtesy of Ed. G. Raser and the W2ZI Historical Wireless Museum.

RADIO ROOM OF SS *PATRIA*, 1921
THIS FAIRLY ELABORATE RECEIVER OPERATES WITH A VACUUM TUBE DETECTOR, AND THE SPARK COIL EMERGENCY TRANSMITTER IS PARTIALLY VISIBLE TO THE LEFT OF THE OPERATOR THE MAIN TRANSMITTER IS NOT SHOWN
Photo courtesy of Emily Ellsworth.

WIRELESS ROOM OF SS *BERENGARIA* (1922)
ILLUSTRATING THE WIDE OPEN CONSTRUCTION OF SPARK STATIONS. THIS ONE SHOWS CLEARLY THE HELIX (UPPER RIGHT USED FOR TUNING THE TRANSMITTER TO A PARTICULAR FREQUENCY AND FOR VARYING THE COUPLING OF THE TRANSMITTER TO THE SHIP S ANTENNA THE TIGHTER THE COUPLING, THE BROADER THE TRANSMITTED WAVE)
Photo courtesy of Emily Ellsworth.

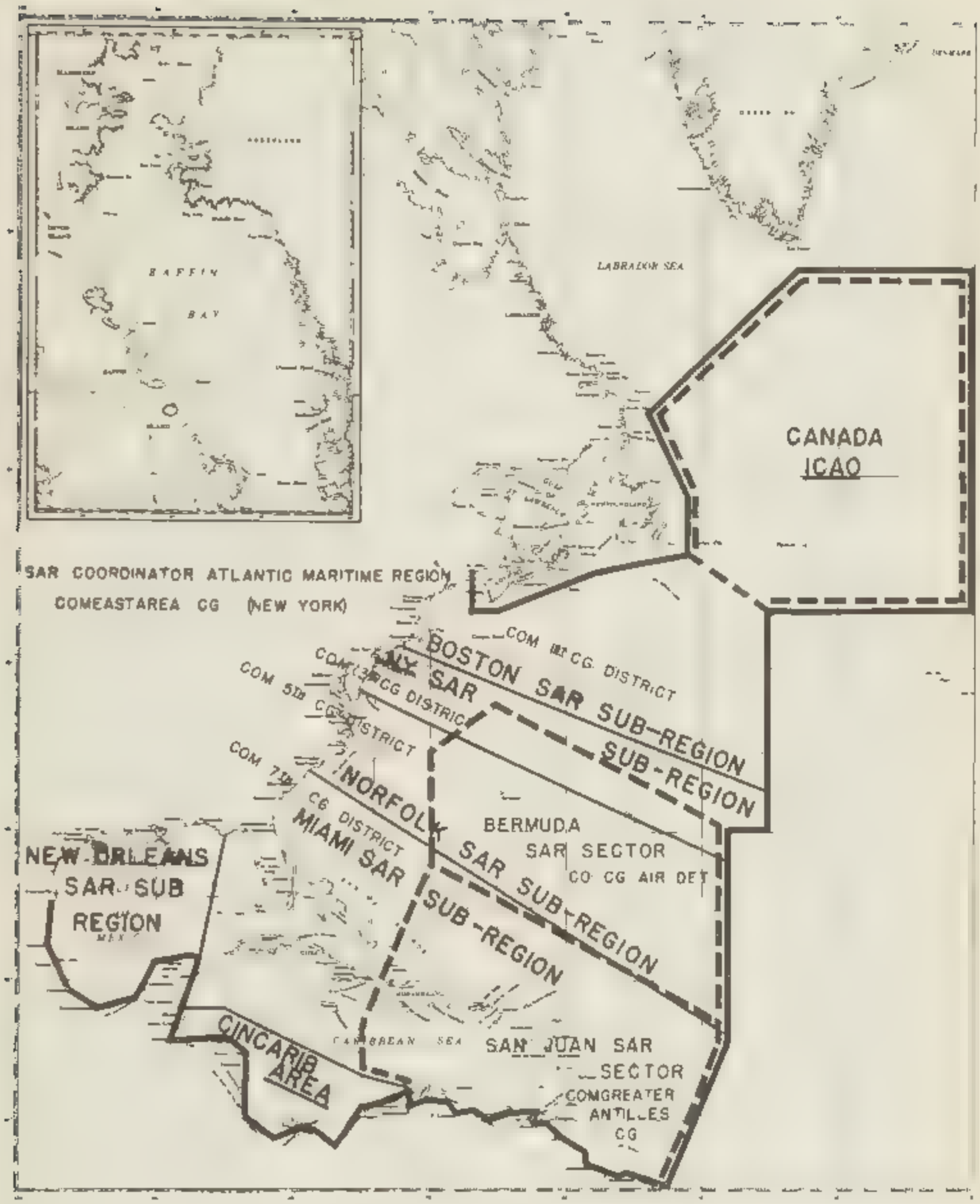


ROTARY SPARK GAP IN OPERATION
THIS UNUSUAL ROTARY WAS PLACED IN OPERATION AT STATION WNW, PHILADELPHIA, IN 1925 APPROXIMATELY TWO FEET IN DIAMETER, IT WAS DESIGNED BY CHIEF RADIOMAN J. DON HAIG, USN THE BAR ROTOR REVOLVED AT HIGH SPEED BETWEEN SECTIONS OF THE SPLIT STATOR, CREATING A MUSICAL AND PLEASING NOTE.
Information and photo courtesy Ed. G. Raser and the W2ZI Historical Wireless Museum.

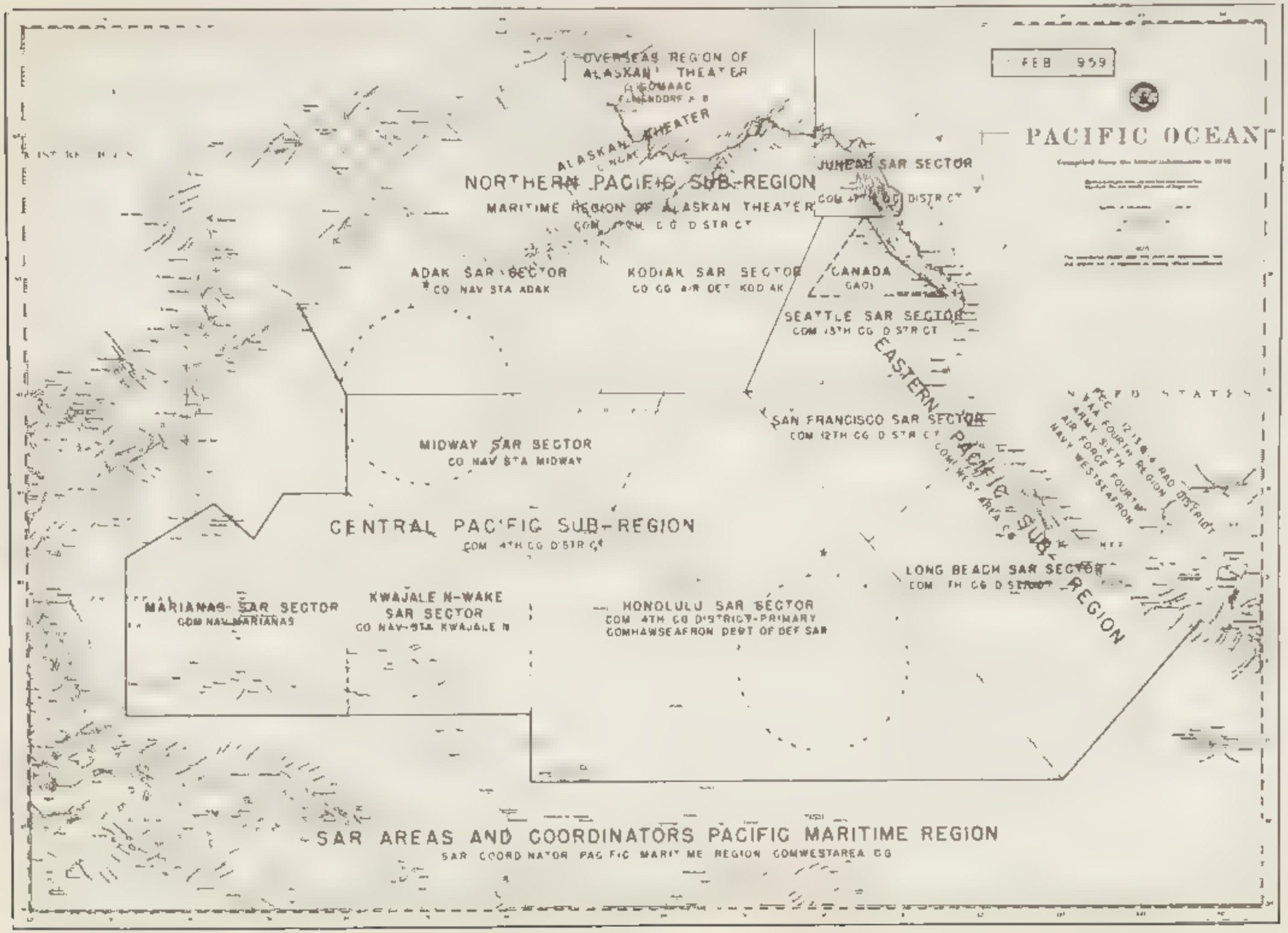


RADIO ROOM OF THE SS *MANHATTAN*
THE EMERGENCY TRANSMITTER IS AT EXTREME LEFT WITH ITS BATTERY POWERED MOTOR GENERATOR PARTLY VISIBLE OTHER EQUIPMENT IN THIS MID-1930 S INSTALLATION COVERED THE LONG MEDIUM, AND SHORT WAVES SPARK HAD BEEN SUPERSEDED BY CW IN THIS STATION.
Photo courtesy of Ed G. Raser and the W2ZI Historical Wireless Museum.

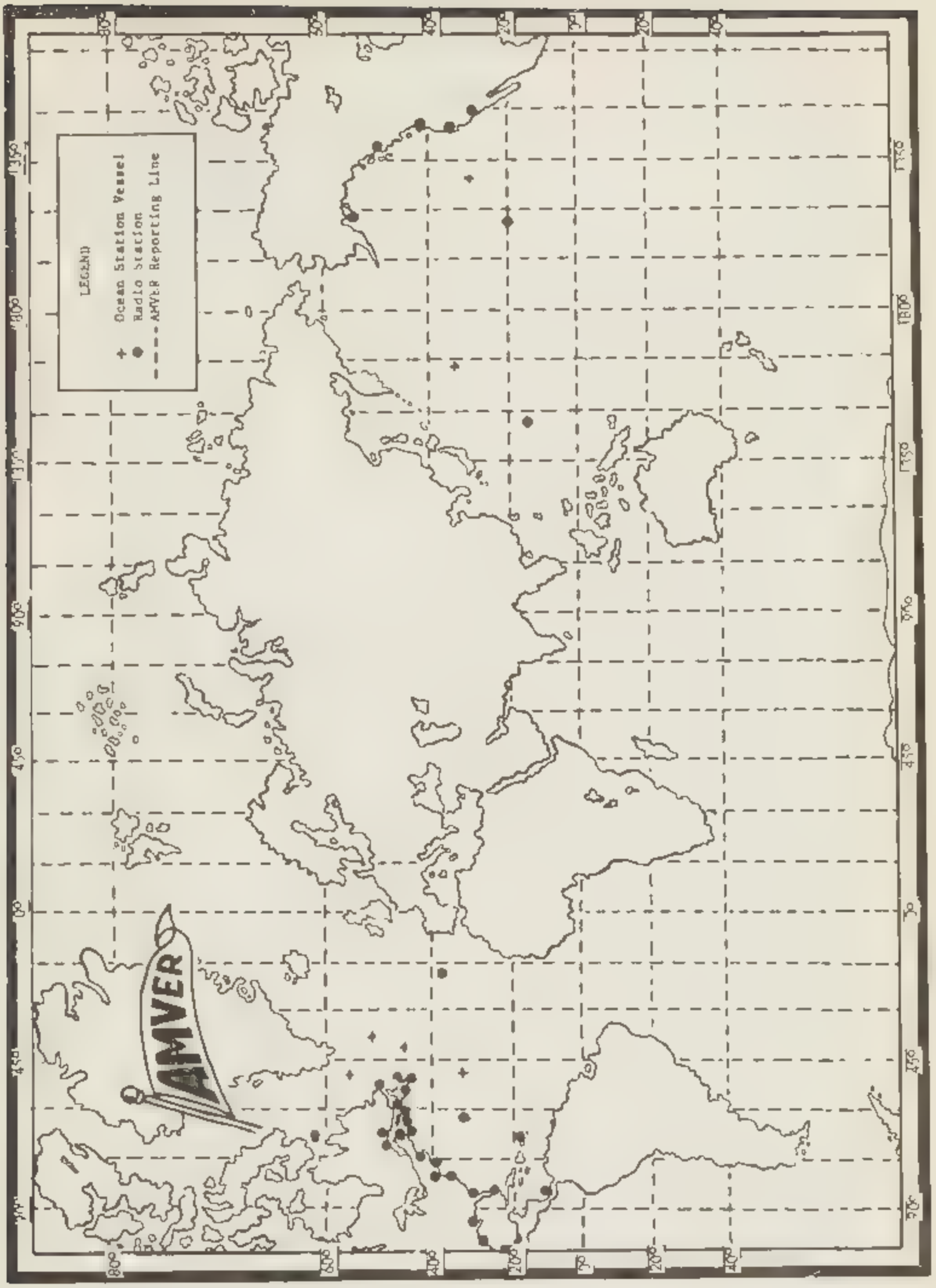
RADIO STATION ON A COASTWISE TANKER



NATIONAL SEARCH AND RESCUE PLAN, ATLANTIC.
From the NATIONAL SEARCH AND RESCUE MANUAL (CG-308)



NATIONAL SEARCH AND RESCUE PLAN, PACIFIC.
From the NATIONAL SEARCH AND RESCUE MANUAL (CG-308).



ONLY U S COAST GUARD MANNED OCEAN WEATHER SHIPS 'OCEAN STATION VESSELS ARE INDICATED ON THIS CHART NOT SHOWN ARE THE OWS S PROVIDED IN THE NORTH ATLANTIC BY OTHER NATIONS UNDER AGREEMENT WITH ICAO.

Courtesy U. S. Coast Guard publication AUTOMATED MERCHANT VESSEL REPORT (AMVER) System

Safety of Life at Sea: Part III

AMVER

INITIATED BY THE U.S. Coast Guard in July, 1958, AMVER[1] (Atlantic Merchant Vessel Reports) has grown into an institution that is making a unique contribution to the safety of life at sea. Embracing the Atlantic north of the equator, AMVER accepts and encourages position reports from ships of all nations plying routes west of the prime meridian, and maintains a computer plot of those so reporting. If accident, serious illness, or distress to a vessel itself occurs, the computer at Coast Guard headquarters in the New York Custom House provides within minutes information on ships within range able to furnish assistance. American naval vessels can, if necessary, be summoned (as has happened several times), data on their movements being available through the Atlantic Fleet Movement Report Center.

The most recent data[2] indicate that the vessels of over sixty nations ply the Atlantic, and of these some 60% report in and are represented on the AMVER plot. Their participation is voluntary, and their reports are radioed to the AMVER center in New York with no cost to the merchant vessel. Any of fourteen Coast Guard and Navy stations along the Atlantic Coast, including the four OSV's, relay such messages free of charge, the main qualification being short-wave radio capability which can make effective communications possible. With the recent addition of twelve Canadian marine stations to the existing network, the number of shore stations accepting messages from ships to AMVER was virtually doubled.[3] Information needed[4] for the most effective functioning of the AMVER data processing system centers not only on the ship's course and speed but on its SAR capabilities as well. This can be submitted in coded groups that furnish maximum data with minimum verbiage. As long as a ship maintains its

course and speed, it can be plotted at AMVER with reasonable accuracy on a basis of dead reckoning. To avoid errors in plot should a SAR or MEDICO emergency arise, ships are requested to notify the Coast Guard of any change in course or speed.

The average daily plot includes approximately 800 ships, the positions of which are automatically advanced by the computer along their known courses. If a ship being called is within range, the frequency of 500 kc is commonly used, with a shift to one of the working frequencies in the same band once contact has been established. All shore stations operating in AMVER service and some Coast Guard vessels also guard the maritime calling frequency bands at 4, 6, 8, 12, and 16 mc.[5] If ionospheric conditions are poor for the high frequency bands, the OSV's are in a position to perform an important relay service. With emphasis on the SAR function of AMVER, merchant vessels capable of doing so are urged (particularly when low-flying aircraft are sighted far off shore) to maintain a radio watch on 2182 kc—the only frequency on which aircraft and surface vessels may sometimes communicate.

Examples of AMVER's function in SAR are numerous, with an average of three alerts a day. A few will serve as illustrations. In September 1962, Flying Tiger Flight 923 had to ditch in the Atlantic, and an AMVER vessel played a major role in rescuing the forty-eight survivors. In December 1960, and American tanker, the SS *Pine Ridge*, broke in two ninety-five miles east of Cape Hatteras during a severe storm. Although she was unable to get off a distress call, her break-up was witnessed by the Norwegian tanker *Artemis*, which broadcast an SOS. AMVER dispatched to the Norfolk RCC a list of predicted merchant vessel positions in the area. It was, however, the carrier USS *Valley Forge* that made the rescue, evacuating survivors by helicopter from the stern section of the *Pine Ridge* under conditions that made conventional rescue procedures by merchant vessels virtually impossible. The forward section of the tanker, sinking quickly, had taken eight men down with it.[6]

When the Greek cruise liner *Lakonia* burned at sea 180 miles north of Madeira on December 23, 1963, AMVER provided the basic data necessary for the most efficient selection of rescue vessels. Within minutes the AMVER computer produced the names and call signs of ships near enough to aid in rescue operations, thus bringing to a coordinated focus an operation that saved 886 lives out of a total of 1041 persons on board the doomed vessel.[7]

The potential of the AMVER plot in furthering safety of life at sea is not, however, limited to distress at sea. When in mid-February,

1964, the island of Sao Jorge in the Azores was rocked by earthquakes, an appeal for assistance was received by the New York Coast Guard. The Commander, U.S. Forces in the Azores radioed for help from shipping in the area to evacuate the 20,000 inhabitants of the stricken island. AMVER was able to radio back the locations and call signs of seventy-four vessels within a 400-mile radius of the island.[8]

International recognition of the value of AMVER was embodied in the 1960 Treaty on Safety of Life at Sea, in which Recommendation 47 urged that "Contracting Governments should encourage all ships to report their positions when travelling in areas where arrangements are made to collect these positions for search and rescue use."[9] The phraseology is pedestrian, but its significance is pointed up by the participation of sixty nations in the program.

Air-Sea Coordination in SAR

After World War II the great increase in over-water flying by both military and commercial aircraft made it necessary to reappraise the resulting problems of communications and of search and rescue. Improved navigational devices developed during the war offered great promise for both air and surface use, with greater assurance of safety as they were perfected. Among the most notable of these were radar and LORAN, both of which have found wide application in air and surface craft. More sophisticated radio equipment of greater versatility and in more compact packages likewise emerged from the pressing needs of war. The transistor, for example, has opened the way to miniaturization of components, as has the increased use of printed circuits—a process greatly accelerated by missile development. One result has been an increase in efficiency along with a reduction in size and weight of units, factors of great importance in designing equipment for use in aircraft. This technological advance, which parallels processes earlier examined in this study, has carried with it the inevitable pains of rapid obsolescence and mounting costs. No satisfactory solution of this dilemma has yet made its appearance.

At successive international radio conferences, the allocation of appropriate and exclusive frequencies in air communications occasioned considerable discussion and often heated debate. Since neither the need of aircraft for such exclusive frequencies nor the urgency attending aircraft emergencies could be denied, the already overcrowded high frequency portion of the radio spectrum had to be juggled and compressed still more as other services gave up bands or portions of bands they had formerly occupied. As earlier described, the maritime service likewise had its special frequency allocations which were

of necessity different from those assigned to the aeronautical service.

This leads to a dilemma familiar in this study. Over both the Atlantic and Pacific Oceans the major airlines use routes paralleling the shipping lanes—no accident, for a great circle route is the preferred one whether by sea or air. This is fortunate for both the maritime and aeronautical services, and in cases of SAR the processes by which one service may assist the other are greatly enhanced. It would be even more fortunate if the communications systems used by the two services could meet at a greater number of points, or frequencies.

It has already been remarked that ships and aircraft may use certain common distress frequencies such as 500 kc (CW), 2182 kc (voice), 8364 kc (CW), 121.5 mc (voice), and 243 mc (voice). At first glance such a wide-ranging cluster of frequencies might seem fairly adequate for the purposes of air-sea coordination, as indeed it is if the aircraft has four engines and versatile radio equipment, and the surface vessel is an OSV with an equally wide range of radio competence. Unfortunately this happily compatible combination is the exception rather than the rule, for the heart of the problem is communications.

The majority of merchant vessels, it will be remembered, carry only one radio operator who stands a total watch of eight hours in a twenty-four hour day. The other watches (sixteen hours) are taken by the auto alarm which, to respond, would have to be triggered by a sufficiently strong signal on 500 kc. There is the possibility, too, that such a distress signal might be intercepted by a ship or shore station that could then rebroadcast it with greater power and at the same time initiate SAR procedure on behalf of the ditching aircraft

By and large, however, it appears that 2182 kc is the frequency on which air and surface craft are most likely to establish communications. For 8364 kc is either a ground-wave or long distance frequency and is not widely guarded by merchant vessels, the emergency voice frequencies (aircraft) at 121 5 and 243 mc are relatively short range, line-of-sight, their coverage being determined by the height of the aircraft. These frequencies, in addition, are rarely guarded by merchant ships. While by no means immune to ionospheric irregularities or atmospheric disturbances, 2182 kc has been demonstrated to have fairly satisfactory propagation characteristics for emergency communications. Its availability in ships and aircraft is far from universal, but its use is increasing. As previously pointed out, it will be mandatory on certain categories of cargo ships, 300-1600 tons, after the 1960 Treaty on Safety of Life at Sea goes into effect. In addition, thousands of pleasure craft and fishing vessels carry radio sets capable of operating on this frequency. The present gap in communications between

ships and aircraft could be largely closed if equipment effective on 2182 kc could be made obligatory for all ocean vessels and for all aircraft making trans-oceanic flights. Whatever the final solution may be to this problem, the international aeronautical and maritime community is fully aware of its urgency.[10]

The U.S. Coast Guard has urged that shipmasters become familiar with the publication *Aircraft Emergency Procedures Over Water* (CG-306), particularly in view of poor communications between ships and aircraft.[11] This publication describes and illustrates in detail, for example, how a pilot by his flight pattern over a vessel—can indicate his own distress and intent to ditch, or his desire to guide the ship to the scene of disaster. In the direst urgency a pilot is advised to ditch across the bow or in the wake of a merchant vessel, which presumably would lower a boat or boats in rescue.

The Coast Guard has also issued and made available to mariners a single-sheet flyer in bold type, setting forth basic procedure for merchant vessels and ditching aircraft. Attempting to bring into play as much as possible of the established SAR technique of the OSV, the merchant vessel is advised to maintain watch on 2182 kc if it is able, otherwise on 500 kc, for relay of aircraft messages by the RCC in control; to activate homing signal on 410 kc; to make smoke; to post extra lookouts; to prepare lifeboats, medical supplies, and Jacob's ladders. For a night ditching the ship is urged to rig buoys with water lights along the ditching route, take station to one side, light up ship, use searchlights as vertical beacons.[12]

Mentioned above[13] is SAR plan ALFA, whereby homing and intercommunication procedures are provided between surface and aircraft along the major Pacific air routes, and by which airlines receive daily notification of ship locations. The larger liners (in addition to the OSV's) with their superior communications and rescue facilities are clearly the best hope for aircraft ditching in both the Atlantic and the Pacific. There have been many instances where a SAR situation has developed into a combined air-sea operation, with aircraft aiding in spotting a distressed vessel, in locating survivors, in dropping life rafts, and in providing communications, while surface vessels have proceeded to the actual rescue operations. The *Ambassador,* the *Lakonia,* and the *Amphialos* are cases in point.

MEDICO

Appropriate to any discussion of safety of life at sea is MEDICO, or medical advice by radio. In matter-of-fact wording, the Geneva (1959) Radio Regulations state that "Mobile stations requiring medical

advice may obtain it through any of the land stations shown as providing this service in the List of Radiodetermination and Special Service Stations." It further adds that MEDICO radio calls may be preceded by the appropriate urgency signal.[14]

On the warmer side is the Italian Medical Center in Rome (*Centro Internazionale Radio Medico*), founded in 1935 by Professor Guido Guida as his own gesture of compassion for ill or injured seamen for whom this service was provided at no cost. This personal venture has grown into an institution with a doctor constantly on duty at the Center, along with a panel of fifty specialists who may be called by turns and who give their services free. Two radio stations enable the Center to make contact with ships at sea and to coordinate its activities, if necessary, with comparable facilities in other countries, such as the U.S. Coast Guard. Now aided by a subsidy from the Italian Government, the Center provides free medical service to over one thousand seamen a year. The account adds that "The Center does not encourage laymen to try to perform operations under radio instruction."[15]

In addition, the principal countries of the world participate in the program of furnishing medical advice by radio, using the medical section of the International Code of Signals to avoid language difficulties.[16] In this way a five-letter code group can convey instructions for medication that would require thirty or more words if spelled out in full, the code groups having the same meaning in all languages. There is still, however, the possibility of a language problem since the medical portion of the International Code of Signals cannot cover every contingency that might be encountered in illness or accident at sea.

The general radio call is RADIOMEDICAL, preceded, if necessary, by the urgency signal. For the United States the call is DH MEDICO. Sixteen U.S. coastal stations will accept such messages, as will Navy and Coast Guard stations guarding the 500 and 8364 kc frequencies, with the U.S. Public Health Service furnishing medical advice.[17] The four OSV's in the Atlantic may also take MEDICO messages, passing them to COMEASTAREA for referral to a Public Health Service hospital. OSV's on stations BRAVO and CHARLIE usually carry a medical officer who may handle a MEDICO case referred directly to his station if he feels that it is within his competence.[18]

Through the facilities of the U.S. Public Health Service, MEDICO, instituted by the United States in 1921, is available twenty-four hours a day to ships of all nations.[19] Action taken in any case is deter-

mined by the diagnosis and recommendations of the United States Public Health Service derived from the patient's symptoms as radioed by his ship. It may be necessary only to radio advice, with medication administered on the ship. Or, in more serious cases, an air drop of medicine may have to be made by a Coast Guard plane, or the patient removed from the ship for transfer to the nearest hospital by cutter, helicopter, or seaplane, depending upon the distance involved and the weather prevailing at the time. For the pilot this can be a frustrating experience if the master of the ship does not understand the procedures necessary for transferring a seaman from his ship to a seaplane. In such an instance the master of the *Taurinia* failed completely to cooperate with a Coast Guard plane that flew out to remove a patient. The ship did not even reduce speed, nor was there a response either to the radio or the visual signals of the PBY. Not until a few days later did a Coast Guard cutter succeed in putting a doctor and a corpsman aboard the vessel.[20]

A MEDICO directed to the United States may be received by the Coast Guard, another government station, or commercial radio. When such a message is received by the Coast Guard, it is passed to the nearest RCC where the duty officer can reach a USPHS physician by telephone. Specialists, who are available on call, may be consulted and a message recommending action then relayed to the appropriate radio station for transmission to the ship at sea.[21]

Occasionally the circumstances are such that the victim of accident or illness at sea can best be treated by a doctor on another ship in the area. In such an instance AMVER is called into action to ascertain whether its ship's plot shows such a vessel within reasonable range. To illustrate, a generator room explosion aboard the Panamanian tanker *Chryssi* some 365 miles northwest of San Juan seriously injured two men. A MEDICO went out to the Coast Guard, and AMVER quickly indicated that among the available vessels was one especially qualified to meet the emergency: the SS *Jerusalem* had not only doctors but a hospital on board. A rendezvous of the two vessels was arranged, and the injured men were transferred to the hospital of the *Jerusalem*. Both men were saved and subsequently landed at San Juan.[22]

MEDICO—medical advice by radio—vividly illustrates one of the many ways in which modern communications have been brought to bear to provide greater safety of life at sea.

SAR in Other Countries

SAR facilities and organization vary widely in different countries of the world but fall into three general categories. Some, like those in

the United States, the USSR, Canada, and Japan are operated by the state. Others, such as those in Great Britain, the Netherlands, and France, are private organizations manned by volunteers. The third category, as in Spain, is privately operated but with financial aid from the government.[23]

The Japanese Maritime Safety Board (MSB), with headquarters at Tokyo, has nine regional headquarters on the islands of Kyushu, Honshu, and Hokkaido. The Guard and Rescue Division (one of six), with rescue work the responsiblity of the regional commander where the disaster occurs, is also responsible for an ocean station vessel assigned to hydrographic and meteorological data gathering, to North Pacific ice patrol, and to icebreaking. Over-all communications maintenance falls to Communications Control Section. The Navigational Aids Division (buoys, lighthouses, etc.) and the Radiobeacon Section control Japanese electronic aids to navigation, including a LORAN Chain operational since 1959. The latter is particularly useful to aircraft using the polar route.

The MSB supports the U.S. Coast Guard Plan ALFA, earlier described—the program of merchant vessel aid to distressed aircraft, and has been an active participant in international geophysical studies.

Patrol boats of the MSB (in the best SAR tradition) picked up the pilots of two USAF jet fighters after their planes had collided off the coast of northern Japan.[24]

Probably the most unusual feature of the SAR organizations in Western Europe is that in most cases they are private, voluntary organizations, financed by contributions, and taking the same degree of pride in their work that characterizes the volunteer fire companies in many American communities.

The oldest of the sea rescue services is said to be the Royal National Life-Boat Institution in Great Britain. A private organization, it enjoys royal patronage, its president being H.R.H. Princess Marina, Duchess of Kent. The lifesaving exploits of these doughty volunteers, often under extreme conditions, are legendary. As with all radio communications ("wireless"), those concerned with distress at sea are the responsibility of the Government Post Office.

There are two voluntary life-boat societies in the Netherlands, using steel motor lifeboats varying in tonnage from ten to fifty, plus motor lifeboats of the beach type. During 138 years of colorful history these two societies have rescued some 12,000 people.

France likewise has two societies: the Central French Life-Boat Society, traditionally directed by an admiral; and the Breton Life-Saving Society, an imposing organization with 160 specialized posts

and 900 safety posts (lifeboats and or shore stations). In 1961 it saved 651 people and aided 447 vessels.

Lifesaving in Spain is the responsiblity of forty-seven coastal stations, privately operated but aided by government grants. A number of individual ones also have their own fund-raising campaigns to help finance their work.

Ships that Disappear

The awesome power of the sea still manifests itself at times with a sudden fury that overwhelms a ship and destroys it before the radio operator can get off a distress call. For example, the British freighter *Nordic Star*, en route from Philadelphia to Le Havre, radioed its position during a stormy voyage on December 27, 1956. It was never heard from again, and extensive air search revealed no trace of the vessel.[25]

The disappearance of the *Marine Sulphur Queen* early in February, 1963, was particularly baffling since the violence of the sea could not be held responsible for her loss. With a cargo of molten sulphur, not regarded as especially dangerous, she was on a routine voyage from Beaumont, Texas, to Norfolk, Virginia, and would have passed at least twenty-one other ships on her scheduled route. Well equipped with radio, plus a radio telephone, she unaccountably disappeared with all hands. Only a few items of debris were recovered in the Florida Straits. Drawing on frustratingly scanty evidence, the Coast Guard report on the loss concluded that the ship had capsized, broken in two, or exploded.[26] Obviously her end, whatever its nature, was so sudden and catastrophic that it was not possible for a ship's officer to pick up the microphone and broadcast her plight—an operation that could have been accomplished in half a minute.

Only the most fortuitous sightings prevented the *Pine Ridge*[27] and the *Amphialos*[28] from joining the ranks of ships that disappeared, for in neither case was it possible to transmit a distress call. For when a ship breaks in two, as several tankers have done, the radio antenna is torn down. Rigging the emergency spare—required to be carried by current regulations—might well be impossible under such circumstances, leaving the ship voiceless though its emergency transmitter might still be operable. A vertical whip antenna, often used for radiotelephone work, might survive a ship's breaking in two, but other factors could prevent its utilization. In the case of ships that disappear, all, however, is speculation since there are no survivors.

Chapter 8 Radio Aids to Navigation

Non-Electronic Navigational Aids

FROM THE DAYS when man first went down to the sea in ships, he has searched for methods of shaping a course to his destination. He felt the necessity of knowing not only where he was going but how to get there most expeditiously In addition he needed to know where he was during the course of a given voyage. The answers to these needs came slowly. Coastal voyaging was relatively simple, and the experienced pilot could check his course and calculate his position in terms of familiar landmarks and coastal configurations. If the vessel were overtaken by heavy weather and poor visibility, navigation became more complicated.

It was not until the fifteenth century that there came into general use navigational devices that made possible voyages of exploration and discovery across the great uncharted oceans of the world. To this process the magnetic compass was indispensable. Invented by the Chinese, it had been introduced to Europe by the Arabs late in the thirteenth century. Its use in navigation, however, required the building of better ships, and it was not until the fifteenth century that its possibilities were more fully exploited. Valuable as the compass was, it merely indicated direction. To determine his position the navigator needed further information, a need partly met by the astrolabe and quadrant The principle of the astrolabe was probably known to the Greek astronomer Hipparchus in the second century B C and, like the compass, it was introduced to Europe by the Arabs, who improved it in the process of passing it along. The astrolabe enabled a navigator to ascertain the angular elevation of celestial bodies and, by consulting his tables, to get a fair indication of his position. The quadrant

performed a similar function, and some mariners carried both instruments. Both were difficult to use on the deck of a ship that was pitching and rolling. The journal of Columbus states that "The Admiral was unable to take the altitude, either with the astrolabe or with the quadrant, because the rolling caused by the waves prevented it."[1] The sextant, invented in 1731, replaced the quadrant, and the improved bubble sextant is still standard equipment on most ships.

For further data in determining a vessel's position there came into use in the sixteenth century a device known as the log, which was, in fact, the ship's speedometer. Attached to a float or log chip was a knotted line with knots 47 feet 3 inches apart. This line was reeled out, using a sand glass and counting the knots, thereby determining the speed of the ship in knots. The record of these readings came to be called the log, which was subsequently expanded into what was really a diary of significant happenings on board the ship. The log chip and knotted line were replaced in the nineteenth century by a towed device carrying a small propeller linked to a dial which registered the distance run with considerably greater accuracy. By the twentieth century a ship's speed was commonly determined by the number of turns made by the propeller, a fairly simple mechanical process by which the turns of the propeller shaft could be read on a dial in terms of knots.

One major gap remained in navigation based on the devices of pre-radio days. While latitude could be determined by the instruments just described, longitude presented more severe problems. A highly precise measurement of time—much more exact than was possible with the clocks of the pre-eighteenth century—was needed. The answer was provided by the marine chronometer, developed by the British John Harrison late in the eighteenth century.

Taking soundings, particularly in waters of uncertain depth, has traditionally been done by using the lead line—a line with a lead weight for measuring the depth of water under the ship's keel. The lead line is still used but is being supplanted to an increasing degree by the fathometer, which provides a virtually instantaneous reading of greater accuracy.

Several of these navigational instruments are still in use: the compass, improved and given greater reliability; the chronometer; the sextant, and the log. Many ships do not carry modern electronic navigational aids and so remain dependent upon devices developed in an earlier day. In foul weather they proceed by dead reckoning, i.e., by compass and log, navigating without reference to external means or celestial bodies. As every experienced navigator knows, serious anoma-

lies may appear in dead reckoning calculations under conditions of heavy seas and high winds. This is especially true when the vessel's speed is derived from the propeller shaft revolution counter. The dial may indicate a forward speed of fifteen knots, whereas the vessel may be making little or no headway.[2]

Other Internal (Self-Contained) Navigational Devices

Their development stimulated by military needs, several devices for precise navigation have become operational in recent years. One of these is SINS (ship's inertial navigation system), which, based on the gyro principle, enables a ship to determine its position and speed as well as true north. Used by nuclear submarines, it makes possible the firing of Polaris missiles with great accuracy. Inertial navigation also enabled nuclear submarines to transit the seas under the polar ice cap. Used by aircraft as well as submarines, this system is equally applicable to surface vessels, but its cost seems likely for some time to come to limit its use largely to naval vessels.

As an additional guarantee on positional accuracy for Polaris submarines, a stellar tracker has been developed and tested by the USS *Observation Island*. This tracker will follow certain stars and planets automatically, providing additional precise information on the ship's position through a continuous flow of celestial data.[3] As installed in Polaris submarines this navigational device is known as SCAR (Submarine Celestial Altitude Recorder).[4] To place SCAR in operation a submarine must surface to periscope depth, with possible risk to security.

The search for still more accurate position-determining devices has resulted in the application of the Doppler effect to navigation, both in the air and on the sea. One of the most evident illustrations of its operation can be noted by an observer as a locomotive, its whistle going, approaches a crossing at high speed. There is an obvious change in the pitch of the whistle due to changing frequency of the sound waves. In its aeronautical application to this effect, radar beams are bounced off the earth beneath the plane, the measurement of the difference in frequency between the transmitted and the received signal providing the data for accurate navigation.

The maritime counterpart of airborne Doppler is called, in one version, the Doppler Navigator, in which sonar beams are projected from the ship as though one were laying out the corners of a large square on the ocean bottom. Data for automatic tracing of the ship's position on a chart are provided by the electronic comparison of the

echo with the transmitted signal.[5] This system is currently undergoing tests by the United States Navy.

What seems to be a redundancy of navigational methods is really a search for better and more accurate systems. It is possible that one system may, after extensive testing and evaluation, supersede another. Or the marriage of two compatible systems could result in combining the best features of both. This has, in fact, already happened in the field of aeronautical navigation with the emergence of radio-inertial and stellar-inertial systems, the latter also being employed widely in missile guidance systems.

Radar emerged from World War II as one of the more promising short-range navigational devices. Improved both as to accuracy and reliability, it is now available for maritime use in several types and ranges varying from one-half to fifty miles. In fog or obscured visibility of any kind it makes possible the detecting of other vessels within range of the equipment, providing data on both bearing and range.

A pulse system, operating in the microwave portion of the radio spectrum, radar operates on the echo principle. A portion of the transmitted signal is returned, electronic measurement of the time lag in the two signals providing the information on both range and bearing of the target. In view of the value of radar as a marine navigational aid, it is astonishing that it has been improperly used so many times. A formidable list of "radar induced" collisions attests not to unreliable or erratic equipment but to human fallibility. For example, in July 1952, the *Baranof* and the *Triton* collided off Canada's Pacific coast. The night was clear, visibility was unrestricted, and the use of radar was unnecessary. The pilot of the *Baranof*, transfixed by the radarscope, failed to act on the warnings of the mate. The pilot was held at fault by the court for "conning a ship by radar . . . he was at fault on that fine summer's night, paying so much attention to the radar and so little to what his eyes could have seen in front of his vessel." In this instance radar distracted the pilot from his job and left him a victim of radar "hypnosis."[6]

Radar provides useful and often essential information, but the latter has to be plotted and evaluated. It does not tell the operator what the next move of an oncoming ship will be, nor can it be regarded as an infallible preventive of collisions or a substitute for good seamanship. Spectacular and needless as the radar-induced collisions are, they are relatively few in proportion to the total number of ships[7] carrying this type of equipment. Unfortunately there is inadequate data on collisions that have been prevented or avoided by skillful use of radar, but such a list would undoubtedly be impressive.

The Coast Guard and the International Ice Patrol for several years have been investigating the possibilities of ice detection by radar. One conclusion was that radar could not be relied upon exclusively to insure safe passage through the North Atlantic iceberg areas. It was emphasized that the radar return from icebergs was only one-sixtieth of that from a vessel of comparable size, and that large growlers were often completely masked by radar echoes from rain squalls or by sea clutter. Further tests showed that seas four to six feet in height could obscure growlers twenty feet high.[8] Obviously icebergs and growlers make poor radar targets, a fact that must be kept very much in mind by ship masters as they move through or near areas where ice is present.

External Aids to Navigation

The first operational radio beacon was set up at the entrance to New York Harbor in 1921, and provided bearings for ships on the basis of their radio transmissions. Such a station provided several bearings for DesRon 11 off the California coast in 1923– bearings that were far more accurate then the dead reckoning calculations of the flagship. There had been many complaints about the inaccuracy of this direction-finding station, and there were serious doubts about it's reliability in DesRon 11. However valid the criticism of these stations may have been, there was a growing conviction that they were unsatisfactory, and they were discontinued in the United States.[9]

More reliable and more numerous than the beacons just noted are the radiobeacons spotted along the coasts of most maritime nations, and operating on the world-wide marine frequency band of 285-325 kc. These radiobeacons are international in that most nations provide them and all may use them Any ship carrying RDF equipment may check its own position by tuning in to two or more of these beacons Published lists of such stations enable the mariner to select those best located to meet his needs, and to identify them positively by the dots and dashes superimposed on a continuous carrier. In the United States these beacons are located at all important harbor entrances and at important intermediate points along the coast There are seventy-six along the Atlantic, Gulf, and Caribbean coasts, and sixty-two on the Pacific coast These beacons can be most effectively used for ranges up to 100 miles, but distances greater than this, particularly at night, may introduce serious errors because of sky-wave contamination.[10] For positional data beyond the effective range of these beacons, the navigator must turn to long range systems such as LORAN, DECCA, and CONSOL.

LORAN (long range aid to navigation) was developed during World War II as a navigational aid for both ships and aircraft. Occupying the 1800-2000 kc band, LORAN A is a pulsed hyperbolic system using a master and one or more slave stations for transmission.[11] From the pulsed, synchronized transmissions, the special LORAN receiver derives a line of position, while two such lines provide a fix. Its range for ground-wave daytime use extends to 900 miles and provides a fix within one mile The skywave at night has a range of 1500 miles and provides a fix within plus or minus five miles.[12]

More sophisticated than LORAN A, LORAN C operates in the low frequency band at 100 kc. The receivers used for this system carry automatic instrumentation (e.g., for search and tracking) and can differentiate between ground and sky waves, thereby insuring greater accuracy in determining a fix. The ground wave accuracy of LORAN C is said to be within 1500 feet.[13] Effective ground wave coverage extends to 1200 miles, and multihop sky waves are usable up to three times this distance, but with reduced accuracy.[14] Put in another way, LORAN C triples the range and increases eight times the accuracy of LORAN A.[15] As of May 1963, there were nine LORAN C stations in operation: two on the east coast of the United States, four in the Norwegian Sea, and three in the Mediterranean.[16]

A long range British development operating in the low frequency portion of the spectrum (200-300 kc), CONSOL is widely used in the North Atlantic region and has a range of 1000 miles by day and 1200 by night. It uses a rotating pattern of dots and dashes and, unlike LORAN, can be received on any conventional communications receiver such as that usually found in a shipboard installation. It has proved useful in ocean navigation despite position-line errors of six to twenty-four miles by day and ten to forty miles by night if located 1000 miles from the transmitter. At night the signal suffers from sky-wave contamination, particularly in the range of 200-400 miles. Useless within twenty-five miles of the transmitter, it cannot be used for making landfalls.[17]

CONSOLAN, another long-range navigational system, resembles CONSOL in many ways. It uses a dot-dash count, employs conversion tables, and can be read on any receiver that covers the low frequencies. With a range of 1000 to 1400 miles, the intersection of two bearings provides a reasonably accurate line of position. At night and at distances of 300-700 miles, readings become virtually useless because of sky wave contamination. A French development, CONSOLAN has one station in the United States on Nantucket (call sign TUK).[18]

It is not difficult to understand why efforts are being made to provide long-range radio aids to navigation that can utilize existing receiving equipment already available on most ships. LORAN, although more accurate, requires special receiving equipment of considerable cost—a factor that might well override the ambiguities present in CONSOL and CONSOLAN.

One more radio navigational aid, DECCA, is being widely used in Western Europe, with experimental chains along the east coasts of Canada and the United States.[19] Operating in the low frequency bands 70-130 kc, it is described as a "hyperbolic, continuous-wave system," that is highly accurate within the limits of its uncontaminated ground wave. Its range of 200-300 miles makes it relatively limited compared to LORAN, CONSOL, and CONSOLAN,[20] but its supporters maintain that it is equal in accuracy to LORAN and superior to the other contenders in the field of maritime and aeronautical navigation.[21] In the search for the *Thresher*, LORAN A was used initially, with the second phase of search based on LORAN C and DECCA (as transmitted from Halifax), making possible the close navigation required in this case.[22]

The goal of the United States in navigation has been a single system capable of meeting the needs of craft that move above, on, and beneath the oceans. With this in mind, the development of OMEGA was pushed in 1958. It was envisaged as a "continuous wave, phase comparison, hyperbolic system," operating in the VLF bands at 10-14 kc. With an estimated range of five to six thousand miles per station, of which eight were planned, it was anticipated that world-wide coverage would be achieved.[23] This is an arduous assignment, for it requires stations as powerful as NAA (at Cutler, Maine) and as accurate as LORAN C. The assignment is formidable as well, for it requires a system adequate for surface ships, aircraft, and submarines, whose needs are not in all respects compatible. It is obvious that a single system would be preferable to the disparate ones currently in use, but it should be remembered that stating the question and answering it are quite different things.

RATAN (radio television aids to navigation), an experimental installation at Sandy Hook, marks a unique approach to the problem of high marine traffic density in the area from the Narrows to Ambrose Light. A "passive" aid, the system transmits a picture of the traffic pattern to those ships equipped with television receivers in the UHF band (670 mc). The telecasts greatly extend the pilot's field of vision, but they do not tell him what to do in any given situation.[24]

Other navigation devices are being designed and tested, as, for in-

stance, an undersea beacon powered by strontium 90;[25] an experimental talking beacon;[26] a new radio range to aid vessels moving up a channel where visual ranges are not visible,[27] a New Zealand invention providing three colored (red, green, white) lights for guidance in a shipping channel,[28] an experimental laser which may do the work of a short-range radar; a radiometer designed to enable patrol planes to spot icebergs through fog and thick weather.[29]

The Transit satellite, designed particularly for precision navigation, is expected to provide a more highly refined fix than other systems currently in use. Four such satellites are now in orbit, and it is anticipated that they will shortly become operational.[30] With the navigation needs of Polaris submarines primarily in mind, it may be presumed that the Transit system will provide position determination more precisely than optical, radio, and mechanical devices now being used (SCAR, LORAN, inertial systems, etc.).

The gains realized in the development of radio aids to navigation are as startling as the progress made in radio itself; in fact it is the latter that has made possible the former. So widespread is the use of many of these navigational devices that any shipmaster who knows where he started and where he is going should experience little difficulty in shaping his course with efficiency and maximum fuel economy. En route he can secure frequent checks on his position and receive, via radio, valuable information on the weather and sea conditions that he will encounter. Nor need the voyager feel alone, for the rest of the world is no farther away than his loudspeaker, his microphone, or his telegraph key.

Chapter 9 Special Maritime Radio Services

Radio Navigational Warnings and Hydrographic Information

MOST COASTAL NATIONS of the world broadcast information regarding such hazards as ice, severe storms, defects in aids to navigation, the position of derelicts. In imminent danger and in an emergency, a broadcast on 500 kc (preceded by the safety signal TTT) is instituted at once. This frequency as well as those at 2182 and 8364 kc is guarded by forty-three Navy, Coast Guard, and CAA stations along the coasts of the United States plus additional Coast Guard stations in Alaska, Puerto Rico, and Hawaii.[1] HYDRO messages are normally dispatched through government facilities, but if this is impracticable, commercial ones may be used.[2]

Emergency information concerning the safety of navigation is addressed to the U.S. Hydrographic Office via the nearest station: HYDRO Washington, Crystobal, San Francisco, or Honolulu. Such messages, if necessary, may be relayed through commercial stations but "never through foreign ones."[3] Information of navigational significance in the Atlantic area is broadcast from Washington (NSS) as HYDROLANTS and is also available to shipmasters in the *Daily Memorandum* HYDROPACS, originating in Honolulu, perform a similar service for the Pacific.[4]

The Coast Guard broadcasts information relating to hydrographic data, weather, storm warnings, and notices to mariners with a preliminary announcement on 2182 kc followed by the informational broadcast on another designated frequency in the 2 mc band. Eighteen stations handle these broadcasts: thirteen on the Atlantic, Gulf, and Caribbean; three on the Pacific coast, and one each in Alaska and Honolulu.[5] All broadcasts are by radiotelephone in the 2 mc band and take place every twelve hours unless an emergency calls for an immediate broadcast. Some of the more powerful Navy stations also broadcast (on CW) hydrographic information of importance to mariners. With their greater power and with the use of several fre-

quencies (121.95 kc, and others in the 5, 9, 12, 17, and 22 mc bands),[7] these stations are able to reach a much larger maritime audience than is possible on the single radiotelephone frequency of 2182 kc.

Radio Weather Aids

Next to ice warnings (in season) weather broadcasts are of major importance to mariners as attested by the fact that some 450 marine stations all over the world engage in this type of broadcast.[8] The listing of these stations in HO 118 gives the area affected, time and frequency of transmission, type of emission (CW or radiotelephone), and power input. Of these the majority stress forecasts and storm warnings.[9]

Also listed are those stations accepting weather observation messages from U.S. radio reporting vessels, giving the locations and the frequencies used.[10] For example, station WSL at Amagansett, New York, uses frequencies varying from 112 kc to 22 mc (fourteen in all); KPH at Bolinas, California, uses frequencies in the range of 126 kc to 22 mc; JCS at Chosi, Japan, broadcasts on eleven frequencies from a low at 131 kc to a high at 22 mc.[11] The wide frequency spread insures that satisfactory copy will be made on at least one frequency even when propagation conditions are not favorable. It will be recalled that the Ocean Station Vessels also play a part in both gathering and disseminating weather data for aircraft and surface vessels.

Time Signals and Frequency Standards

As earlier described,[12] accurate time measurement is essential to precise navigation—an accomplishment made possible by the marine chronometer. The latter, however, has to be checked at intervals, with radio time signals providing the standard. This service is furnished by many radio stations in various parts of the world, e.g., New Delhi, Paris, Tokyo, Buenos Aires, Moscow, Beltsville (Maryland), and Rugby (England).[13] Since 1960 close coordination in the transmission of frequency and time signals has been achieved between the United Kingdom and the United States. In view of the scientific needs presented by the tracking of artificial satellites, radio communications, and geodesy, uniformity in this program should be world-wide.[14] Their accuracy checked by atomic standards, the time and frequency broadcasts of WWV are among the most accurate in the world.[15] These signals are broadcast constantly on a twenty-four hour basis[16] and on a number of frequencies (2.5, 5, 10, 15, 20, and 25 mc) insuring world-wide coverage as long as propagation conditions are fairly good.

The frequency standards used in WWV broadcasts make possible the checking of the calibration of a ship's receivers as well as its frequency measuring equipment. As seen earlier [7] an accurate frequency check is necessary so that a ship's transmissions will meet the technical standards defined in the most recent radio regulations. Needless to say, the time signals and frequency standards broadcast by WWV can be used advantageously by services other than the maritime mobile.

Propagation Disturbance Warnings

Forecasts of radio propagation conditions from WWV, until recently broadcast twice during each hour, are now transmitted every five minutes in International Morse Code –after the station identification (also in International Morse Code) and preceding the time announcement by voice. Data for these forecasts are gathered from radio soundings of the upper atmosphere, high frequency reception, and world-wide nets of solar and geophysical observatories. These data are analyzed by experts at the National Bureau of Standards Central Radio Propagation Laboratory (NBS-CRPL) and provide the basis for the warnings broadcast with reference to the North Atlantic radio paths.[8] A similar service is provided for the North Pacific by station WWVH (Hawaii).

These warnings are transmitted as a letter and a digit, the letters being "W" (disturbed), "U" (unsettled), and "N" (normal). The digits run from 1 (useless) to 9 (excellent). If, for example, conditions at the time of the broadcast were normal but expected shortly to deteriorate, the announcement in code would be N3, indicating the development of poor conditions in the period following.[9]

Such propagation disturbance warnings are of particular value to the maritime mobile service which is dependent for its communications upon radio and has no alternate method of contact. If, therefore, a periodic report is due to be transmitted to the ship's home office in the next four or five hours, or if low priority messages have been accumulating, it would be wise to "clear the hook" while the high frequency bands were still open. While WWV can forecast a developing period of ionospheric disturbance, it cannot at the same time predict when the disturbed condition will cease.

Since the purpose of the WWV broadcast is to provide the services of the station to as wide an area as possible, all antennas are omnidirectional verticals. The broadcasts on 2.5 mc use a vertical quarter-wave, while the other frequencies use vertical half-wave dipoles.

Considering the signal strength with which WWV may normally be received by ships at sea and at varying distances from Beltsville, the radiated power of the station is not high. On 2.5 mc the radiated power is 1 kw; on 5 mc it is 8 kw; on 10 mc it is 9 kw; on 15 mc it is 9 kw; on 20 mc it is 1 kw;, and on 25 mc it is only 100 watts.[20] Attention was earlier directed to the low frequency (60 kc) station WWVB at Boulder, Colorado.[21]

Facsimile

Another special radio service that has become operational in the past five years is facsimile.[22] Particularly useful during the ice season in the Northwest Atlantic, facsimile can be utilized wherever a ship is within range of a transmitting station. Presenting a picture of weather or sea conditions, for example, it offers data far more quickly and graphically than would be possible in a message tapped out letter by letter in International Morse code. This machine should, therefore, have a secure place among the devices developed to ensure greater safety of life at sea.

MERCAST

In the event of war or national emergency, all shipping under United States jurisdiction will come under naval control, and all such ships at sea will be directed by the appropriate naval command. The communications system that will operate under such circumstances is known as MERCAST (merchant ship broadcast). An emergency message from the Chief of Naval Operations will actuate the system, and supplementary messages will be broadcast by designated areas.[23] The Atlantic OSV's will also broadcast the emergency message hourly for twenty-four hours on 500 and 8364 kc.

MERCAST areas are defined, enabling ships at sea to know in what area and under what naval jurisdiction they fall. Ships will be advised as to their courses in order avoid serious danger zones, and may be diverted or recalled at the discretion of the naval commander having jurisdiction. Radio silence is to be broken only in case of emergency.[24]

The NATO MERCAST system designates the Eastern and Western Atlantic and the Mediterranean areas in which NATO nations will provide MERCAST from their shore stations. Instructions list frequencies, hours of operation, call signs, and station locations. Frequencies range from 115 kc to 22 mc, by means of which United

States merchant ships in foreign ports or at sea may receive essential information in the event of war.[25]

Communicating with Polaris Submarines

A by-product of the Cold War, the growing fleet of nuclear submarines has added a new dimension to the art of maritime communications. As seagoing and submersible missile launching sites, these vessels derive their strategic capability in part from the missiles carried, and in part from the fact that they can, if necessary, remain submerged and undetected for weeks. Of prime importance in their strategic role is communications, for the order to launch a missile strike must come from the President himself.

Getting instant word to a submerged vessel halfway around the world has proved a difficult process, yet this has to be done if the new submarines are to perform their functions of deterrence and attack. Shunning the high frequencies because of their limited ground-wave coverage as well as their often erratic behavior, research indicated that the VLF portion of the radio spectrum would have to be used. Added reliability lay in the fact that the VLF are little affected by ionospheric disturbances that can cripple communications on the high frequencies. It was also evident that great power and elaborate antennas would be required if the stability of the VLF bands were to be fully exploited.

The first station erected for this purpose was at Jim Creek in the Cascades, and it was at first assumed that this one station could satisfactorily push its signals to submerged submarines in all the oceans of the world. These expectations were not, however, fulfilled, and a second station, with a power of two million watts, was built at Cutler, Maine.[26] Operating on frequencies as low as fifteen kilocycles the new NAA still did not meet fully the expectations of its designers. Consequently a third powerful VLF station was built, this time on the west coast of Australia.[27]

Although a submarine can receive radio signals while submerged, it cannot at present transmit. Only when surfaced, with its whip antenna well out of the water, can it engage in two-way radio communications. This can be done only when its security will not be jeopardized and when, obviously, its position is known—as in transiting the Suez Canal.

Impelled by strategic needs in an age of nuclear weapons—an age in which expense is no deterrent—the VLF system now in operation has opened up promising new possibilities for communications at the low end of the radio spectrum.

Chapter 10 Final Considerations

The Past: Accomplishments

UNTIL THE TWENTIETH century men sailed alone, remote in silence, until they hailed a passing ship or reached a port. For contact at sea remained as undeveloped as it had been in Noah's time, with visual distances determining the extent of communications. By contrast, a century earlier, the railroad, the telegraph, the telephone, and the submarine cable had expedited land communication. But despite improved ship construction, the replacement of sail by steam, and the development of more effective navigational devices, the need for maritime communication remained.

Early in the twentieth century Guglielmo Marconi altered this pattern. Drawing on the discoveries of others and adding new inventions of his own, he made available to the maritime community the first workable system of wireless telegraphy. Like the contemporary efforts of the Wright brothers, his first experiments were viewed by most with skepticism. As though to rebuke the scoffers, radio and powered flight eventually merged in the art of aeronautical communications. Unprejudiced as to the medium in which it could travel, radio almost at once became international in character. Ship-to-ship and ship-to-shore contacts broadened in time to include ship-to-aircraft as part of the accepted pattern of contact at sea, on land, and in the air.

The early years of wireless were distinguished by two developments, the first of which was marked by the efforts of Marconi to label wireless as exclusively his own a position challenged by other companies and countries. The early international conferences were scarred by this struggle, and it was not until the shock of the *Titanic* disaster that the supporters of Marconi yielded.

The second important development in the early years was technologi-

cal—the attempts to produce more reliable apparatus capable of spanning greater distances. The Fessenden rotary gap, the Alexanderson alternator, and most of all the De Forest audion opened the way to a drastic break-through in the field of maritime communications. Of equal importance was the opening up of the short waves in the early 1920's—a development that hastened the showdown between Spark and CW at the same time that it precipitated new and complex problems of frequency allocations. Ingenious devices were developed in the interests of radio spectrum conservation, only to have such gains wiped out by still greater demands for frequencies.

To insure dependable communication with other ships and with land, it might be assumed that ship owners would install radio equipment with alacrity. But in many instances the cost so effectively deterred them that it became necessary to legislate various categories of ships into compliance. This process, which covers half a century, is best seen in the succession of general radio conferences and the conferences on safety of life at sea national legislation being necessary in both cases to implement decisions taken at the international conferences

The process of requiring larger catagories of ships to carry radio was accompanied by far-reaching technological advance in the art itself Spark reluctantly gave way to CW as the vacuum tube demonstrated its superior characteristics for both transmitting and receiving. The vacuum tube opened the way to an entirely new mode of transmission—the radiotelephone—the social benefits of which are still being debated, but the utility of which to maritime communications is beyond question. New applications of the vacuum tube augmented the safety of life at sea, as in the case of radio direction finders, radar, and the auto alarm. So it was wi ingenious navigational aids that enabled a master at all times to know his position with precision Although not recommended practice, it had become quite possible through the use of LORAN, radar, direction finders, the compass, and radio for a master to chart his course from New York to Brest without looking beyond the confines of the bridge or wheel house By radio he could learn of the weather prospects along his course and of any hazards to navigation that he might encounter. In case of accident or illness among passengers or crew he could radio MEDICO for advice, administering treatment in less time than it would take for the family doctor to get into his car and drive to the patient's home.

If, despite the magic ministrations of radio, his vessel should be imperiled, he need only dispatch a distress call to put into operation the complex machinery of SAR. Within minutes other ships, their locations and capabilities indicated by AMVER, would be steaming

to his assistance. If necessary, aircraft as well would be directed to participate in the search and rescue procedure. If the distressed craft were a plane, the pilot could count himself fortunate if an OSV were at hand for the ditching. In any event the pilot or master would know that all the resources possible would be mobilized on his behalf, and that by virtue of radio his welfare and survival were of prime concern to all within sound of his voice.

For compared to the wireless of fifty years ago, the advances of modern radio are startling. No longer is contact at sea indeterminate. In time of distress an automatic device transmits the SOS, while in most cases it is registered on another vessel by the auto alarm, in part bypassing human frailty at the critical moments both of transmission and reception.

Moreover, the elaborating and perfecting of radiocommunication has occurred at a time when the need for its services parallels the striking increase in international trade and sea and air travel. While some of the foremost technological advances in radio emerged from the exigencies of war, with its cessation these same gains have quickly been turned to the benefits of peace and the safeguarding of human life.

Finally, the field of maritime communications presents an impressive example of international cooperation on a global scale—in the acceptance and general observance of rules which solitary sovereignties may violate at their peril. Thus self-interest becomes the general welfare as the two coincide. Perhaps in spite of itself the international community has given a high priority to the value of human life. For in view of the fact that maritime radio is hardly more than a half century old, at few times in history have so many come to terms on so much in so short a time.

The Future: Problems and Prospects

Considerable attention has been directed earlier in this study to the technological advance in the art of maritime radio communications, to the reluctant demise of Spark, and to the greater efficiency for contact at sea and the safety of life resulting from these advances Highly revealing in this context is the increase in the number of ship and shore stations since 1920. For example, in that year the Berne Bureau listed 977 shore stations and 12,622 ship stations. By 1959 the number of shore stations had increased to approximately 4500,[2] and the number of ship stations (as of 1962) to an estimate 40,000.[3] In terms of these numbers, without modern apparatus and a carefully worked

out system of frequency allocations, contemporary maritime radio communications would deteriorate into unimaginable confusion and frustration.

In view of the impressive increase (which shows every sign of continuing) in the number of ship and shore stations in the maritime service, it would seem no more than reasonable to anticipate more generous frequency allocations for this service in the future. To report that the winds are favorable in this direction would be pleasant but, at this point, unduly optimistic; for the radio spectrum is shared by many services besides the maritime. Of these the more important are the aeronautical, broadcasting, fixed, amateur, special (time signals, meteorology, frequency standards, etc.), and the experimental. For many years this radio spectrum has been severely congested as the demands for frequencies have far exceeded the number available for allocation Insofar as maritime radio is concerned, therefore, it would seem to be a question less of securing more frequencies than of avoiding losses in those currently in use.

Mention has previously been made[4] of the fact that broadcasting short wave particularly and the military are the most voracious users of spectrum space. This leads one to examine, with misgivings, the proximity of these hungry services to the maritime service in the table of frequency allocations.[5] Remembering that the military services are not listed here as such, but find their necessary frequencies under other headings such as "fixed" and "aeronautical," some interesting reflections present themselves. As users of frequencies adjacent to those assigned to the fixed services, for example, the maritime allocations are in many cases in a prime position to be reduced as their neighbors expand.[6] The trend at previous radio administrative conferences has been expansion for the more aggressive services at the expense of their neighbors, a precedent that keeps the maritime service glancing nervously over both shoulders at the same time. To illustrate, the fixed services nudge the maritime on ten bands below 3 mc, and on fifteen bands between 3 and 27.5 mc (the high frequencies, most hotly contested of all), and on eighteen bands between 27.5 and 300 mc. (VHF).

To cite an additional instance, broadcasting below 3 mc is adjacent to the maritime on five bands; on 3-27.5 mc, eight bands; on the VHF frequencies (27.5-300 kc), eight bands. In other words, the fixed (i.e. military) and broadcasting services bracket the maritime frequencies on a substantial number of bands below 300 mc. This does not make for optimism in maritime communication circles. Further revealing is the present ratio of broadcasting to maritime frequencies

in the HF portion of the radio spectrum about three to four. It seems reasonable to speculate that an increase in favor of broadcasting would hardly be dictated by the demonstrable needs of the international community.

Barring an unexpected reversal of existing trends, what can the maritime service do in the face of a double squeeze—from its own increasing numbers and from other services seeking some of their additional frequencies at the expense of the maritime? It is quite possible that new and ingenious devices not yet on the drawing boards may contribute to greater conservation of spectrum space. Undoubtedly there will be an accelerated move to single sideband radiotelephony where feasible for maritime needs. High density CW traffic circuits will have to employ radioteletype and multiplexing on a more extensive scale, but the benefits of this for most ship and shore stations do not loom immediately ahead. SYNCOM satellites may provide an artificial ionosphere that could greatly expand the applicability of VHF and UHF frequencies, but again, the benefits of this technique for ships at sea will be long in coming. Here the hopeful possibility is that these developing techniques can ease the pressures on other services that currently are eyeing the maritime frequencies with less than complete objectivity.

Most important of all, however, is the need for preserving those frequencies that are most significant in maintaining and extending the safety of life at sea. on the basis of which the elaborate mechanism of Search and Rescue has evolved.

A second problem,[7] inherent in the incompatability of two distress frequencies (500 and 2182 kc), promises no easy solution. Vastly important as it is to safety of life at sea, there seems to be no way completely to avoid the possibility that within rescue distance of a marine disaster a ship may be deaf. It has been suggested that the gap could be partly closed by requiring vessels equipped with radiotelephone in addition to carry the survival type of gear (the Gibson Girl or its successor) that would automatically or manually transmit the CW distress call on 500 and 8364 kc. This would give added protection to the vessels also equipped with radiotelephone but would not require a CW operator; it still would not, however, enable such a vessel to hear a distress call on 500 kc. A further closing of the gap would be possible if ships carrying CW equipment for 500 kc were also required to install radiotelephone gear for use on 2182 kc, enabling such vessels to transmit a distress call on both 500 and 2182 kc, as well as being able to receive on both frequencies. While 500-kc CW is more efficient than radiotelephone on 2182, the per-

fecting of the auto alarm for radiotelephone will certainly add to the latter's effectiveness in distress cases.

Such dual installations would be both clumsy and costly, adding perhaps five hundred dollars to the ship's bill for radio equipment, circumstances to give pause to the operator of a narrow profit margin vessel. Considerations for the safety of life at sea have, however, overridden the objection of cost and conceivably could do so again. Only the larger passenger vessels currently have this dual capability, the SS *United States*, for example, being able to operate on the CW frequencies of 110-150, 1605-3800, 4000-25,100 kc; as well as with radiotelephone on 1605-4000 and 4000-23,000 kc, with continuous radio watches.[8]

The final consideration of this study is the human factor—indispensable and unpredictable. When rules and regulations, when advanced technology have done their utmost, man finally determines their usefulness. For here no directives, no automation can replace human judgment, skill, and courage. Though conceivably a ship's captain can chart his course without stepping outside the wheel house, neither laws nor technical inventions can determine for him whether to send out an SOS or contact MEDICO. Even in the semi-automated aspects of maritime communications—in teletypewriter circuits, for example—the tape has to be cut by skilled human hands before it can be fed into the transmitter for high-speed operation Even the automatic keyer now required for distress calls on 500-kc CW has to be installed, properly adjusted, and placed in operation by a skilled operator. So it is with virtually every aspect of life on a ship at sea.

As normal operations require able men, how much more do crises! For the value of the human equation manifests itself at practically every vital step in the SAR process, placing a premium on intelligence, training, discipline, and selflessness. Fortunately the examples of negligence and incompetence that have cost lives in marine disasters are happily outnumbered by the instances in which life has been saved by prompt and courageous action.

In contemporary maritime radiocommunications it is the human factor that is both strongest and weakest Its perfecting involves considerations beyond the scope of this study.

Appendix A

The Marconi Station at South Wellfleet

The South Wellfleet station is of unusual interest not only as a Marconi "first," of which there are many, but as a typical wireless station of the early years and the first in the United States to send and receive a transatlantic message. For it was from here on January 19, 1903, that Marconi himself transmitted a message from President Roosevelt to King Edward VII and received the King's reply. This message, as it is transcribed on a plaque at the site of the exchange, is reproduced in Appendix. B. The station proved unable, however, to maintain consistent transatlantic message handing and was subsequently operated to broadcast news and messages to ships at sea. By one of the peculiarities of propagation it was heard loud and clear more often in Buenos Aires than in England.

According to the pattern of shore stations of its day, WCC (earlier call letters were CC and MCC) was built on a high sand dune overlooking the Atlantic. The sand, however, made a poor electrical ground and so reduced the efficiency of the transmitter that an unsuccessful attempt was made to pump sea water from the ocean to provide more moisture for the base. The erection of a counterpoise was similarly disappointing. But despite these handicaps, broadcasts from WCC's 35 kilowatt transmitter were picked up by ships at a distance of 1000 miles, after which they were taken over by the station at Poldhu, England.

The original antenna, supported by tall poles arranged in a circle, could not withstand the ferocity of Cape Cod northeasters. But a replacement antenna, hung from four guyed latticework towers each 210 feet high, proved considerably more durable, and WCC's broadcasts to ships—the transmitter actuated by hand-cut tape—thereafter went out with regularity. The running of a direct telegraph line to the station necessitated the use by operators of both Morse and Continental codes—the latter for wireless –no mean accomplishment. The station generated its own power at the site, and the transmitter in operation was an experience that veterans can never forget. The rotary spark gap (a Fessenden invention) could be heard and seen for miles as a grapefruit-size spark flashed between the lugs on the three-foot

rotary and the stationary electrodes. An unusual feature of the station was the keying of the transmitter in the high voltage secondary, with a blower to extinguish the arc between the keying contacts.

Taken over by the Navy in World War I, WCC was shut down and its equipment removed. Today little remains at the historic site except a concrete platform where the transmitter station was located. The two seaward towers are gone, claimed by the Atlantic, while the wood of the buildings has long since furnished thrifty Cape Codders with firewood. The bluff itself is eroding four to five feet a year, and only a fragment of the power station platform can still be seen on its receding edge.

The WCC site and Camp Wellfleet of World War II are now designated the "Marconi Station Area," a part of the Cape Cod National Seashore and one of the four Cape areas currently under the jurisdiction of the National Park Service. A model of the original station, painstakingly constructed to scale by Mr. Fred Parsons, is now on display at the site.

Appendix B

Following is a transcription of the first transatlantic wireless message* sent from the United States to Great Britain. Marconi himself operated the transmitter on this historic occasion.

His Majesty, Edward VII, London, England

In taking advantage of the wonderful triumph of scientific research and ingenuity which has been achieved in perfecting a system of wireless telegraphy, I extend on behalf of the American people most cordial greetings and good wishes to you and to all the people of the British Empire.

Theodore Roosevelt

Wellfleet Mass., Jan. 19, 1903.

*From a transcription on display at the original station site. The code symbols used by Marconi in this historic transmission can also be seen in the same display, made available by the late Irving Vermilya, formerly an operator at and later manager of station WCC at the time of World War I.

Appendix C Glossary

1. Abbreviations

ALFA: Phonetic spelling for letter "A", as in Plan ALFA

AMVER: Atlantic (Automated) Merchant Vessel Reports

ASW: Anti-submarine warfare

COMEASTAREA: Commander Eastern Area

CONSOL: Long range navigational system

CONSOLAN: Long range navigational system

CQ: General call used in radiotelegraphy

CQD: Radio distress call superseded by SOS

DECCA: Medium range (200-300 miles) navigational aid

FAA: Federal Aviation Agency

FCC: Federal Communications Commission

IARU: International Amateur Radio Union

ICAO: International Civil Aviation Organization

IFRB: International Frequency Registration Board

IGY: International Geophysical Year (1957-1958)

IMCO Intergovernmental Maritime Consultative Organization

IQSY International Quiet Solar Year (1964-1965)

IRAC Interdepartment Radio Advisory Committee

ITU: International Telecommunication Union

LORAN: Long Range Aid to Navigation

MEDICO: Medical Aid by Radio

MERCAST: Merchant Ship Broadcast

MSB: Maritime Safety Board (Japan)

NBS-CRPL: National Bureau of Standards—Central Radio Propagation Laboratory

NSRP: National Search and Rescue Plan

OMEGA: Experimental very long range navigational system

OSV: Ocean Station Vessel

OWS: Ocean Weather Ship

PICAO: Provisional International Civil Aviation Organization

RADAR: Radio Direction and Ranging

RATAN: Radio Television Aid to Navigation

RCAF: Royal Canadian Air Force

RCC: Rescue Coordination Center

RDF: Radio Direction Finder

SAR: Search and Rescue

SCAR: Submarine Celestial Altitude Recorder

SINS: Ship's Inertial Navigation System

SOLAS: Safety of Life at Sea

SONAR: Sound and Ranging—underwater detection

UHF: Ultra high frequencies (300-3000 mc)

USPHS: United States Public Health Service

VHF: Very high frequencies (30-300 mc)

VLF: Very low frequencies (3-30 kc)

WMO: World Meteorological Organization

Appendix C

2. Definitions

Alternator: A generator of radio frequency energy used for VLF (long wave length) radio transmissions.

Auto alarm A receiving device that automatically responds to a properly transmitted distress call, e.g., by the ringing of an alarm bell.

Carrier A transmitted radio frequency signal of a specific frequency which can be keyed for radiotelegraphy or modulated for radiotelephony.

Convention An international agreement—in this connection one dealing with radio matters.

CW: Literally, continuous wave, and used as a general term to indicate the type of radiotelegraph transmission that superseded spark

Damped waves: Electromagnetic waves of diminishing amplitude, such as those produced by a spark transmitter (Type B waves).

Frequency The number of cycles per second in an electromagnetic circuit. One kilocycle (kc) is 1000 cycles per second; a megacycle (mc) is 1000 kc; a gigacycle is 1000 mc.

Frequency tolerance The maximum permissible deviation from a central radio frequency of a transmitted signal.

Gibson Girl: A compact emergency transmitter, so called because of its narrow-waisted configuration.

Ground wave: That portion of a radio wave that travels parallel to and close to the earth's surface. A significant factor in transmission at low frequencies, but negligible at high frequencies.

Modulated CW: A mode of transmission in which an audio tone is superimposed on the fundamental carrier. Is also designated as A2.

Multiplexing: The use of a common radio carrier wave for simultaneous transmission of two or more signals.

Power amplifier: The last stage of a radio transmitter that amplifies the output of the oscillator and intermediate stages to the extent necessary for effective radio communications. Is expressed in watts, kilowatts, or megawatts.

Public correspondence: Exchange of messages by non-military radio stations.

Pulse System: A type of emission characterized by short bursts of high power, as in RADAR or LORAN.

Radio spectrum A term used to indicate the range of radio frequencies suitable for transmission of radio signals, e.g., 10 kc—40 gc, the present limits of the world-wide allocation table.

Radio wave propagation: The transmission of radio signals to receiving stations at varying distances, employing ground wave and or sky wave (q.v.) techniques.

Rectifier: A device, of which the two-element vacuum tube is one example, which permits the passage of electric current in one direction only. By this process alternating current is rectified into direct current as required for certain radio applications

Single sideband: A type of radiotelephone transmission using upper or lower sideband with reduced or suppressed carrier. Is less subject to fading, cuts through better than conventional radiotelephone, and occupies only about one-third of the bandwidth. See "Carrier."

Skywave A characteristic of the high frequencies (short waves) particularly. The radiated signal is reflected back to earth from the ionosphere, perhaps with several hops, making possible long distance high-frequency communications.

Sky wave contamination As one illustration, it is occasioned when a sky wave impinges on a ground wave. Since a sky wave takes a longer path, it lags behind the ground wave signal, causing distortion or contamination.

Spark A type of emission in which the transmitter uses either a fixed spark gap or a rotary gap. The emissions are also called Type B waves.

Transmission mode The type of transmission used, e.g., CW, radiotelephone, pulse, etc.

Undamped waves Electromagnetic waves of constant amplitude, continuous waves, hence CW as produced by an alternator or vacuum tube transmitter.

Appendix D

SAFETY OF LIFE AT SEA CONFERENCES (RADIO)

YEAR	CATEGORY OF VESSEL	RADIO GEAR REQUIRED	EMERGENCY GEAR	WATCHES	RDF
1914	Over 50 passengers	With 100-mile range (Spark) radiotelegraph	If over 50 passengers	Continuous if over 50 passengers	
1929	All passenger ships*	With 100-mile range (Spark) radiotelegraph	80 or 50 mile range. Independent source of power	Continuous over 3000 tons Auto alarm or certified watchers permitted	Passenger ships over 5000 tons
	Cargo ships over 1600 tons*	With 100-mile range (Spark) radiotelegraph	50 mile range	Under 3000 tons Administration determines. 3000-5500 tons 8 hrs. per day Over 5500 tons continuous. Auto alarm or watcher and qualified operator.	
1948	All passenger ships* Cargo ships over 1600 tons*	A2 150 miles	100 miles Spark permitted	Continuous unless auto alarm. At least 1 qualified operator. Listening hours prescribed.	Required for ships over 1600 tons.* medium frequency

Appendix D

SAFETY OF LIFE AT SEA CONFERENCES (RADIO)

LIFEBOAT RADIO	NAVIGATIONAL GEAR	FREQUENCIES	DATE IN FORCE	*GENERAL RADIO CONFERENCES*
				1912 London
		600 m. 300 m.	Not Ratified	
	RDF (Radio compass)	600 m.	1936	
				1927 Washington
		600 m.	1936	
				1932 Madrid 1938 Cairo
				1947 Atlantic City
CW installation in Class A motor lifeboats. Portable gear if over 20 lifeboats carried.	RDF	500 kc 2182 kc 8364 kc	1952	

Appendix D

SAFETY OF LIFE AT SEA CONFERENCES (RADIO)

YEAR	CATEGORY OF VESSEL	RADIO GEAR REQUIRED	EMERGENCY GEAR	WATCHES	RDF
1948	Cargo ships 500-1600 tons	A3 150 miles	Same as regular. Separate emergency power supply in new installations	Any crew member with A3 certificate. Hours specified by Admin.	
1960	All passenger ships*	A2 150 miles Automatic CW alarm keying device** Automatic alarm receiver**	100 miles*	Continuous unless auto alarm. Listening hours determined by number of passengers.	All ships* over 1600 tons
A3	Cargo ships over 1600 tons	See** A2 150 miles	See** 100 miles		
	Under 1600 tons Or 300-1600 tons	A2 100 miles A3	75 miles	Continuous by A3 operator or speaker on bridge	
	Or 500-1600 tons	A3 150 miles	Watch receiver pre-set on 2182 kc		
	Or 300-500 tons	As 75 miles			
	Automatic radiotelephone distress signal				

Appendix D

SAFETY OF LIFE AT SEA CONFERENCES (RADIO)

LIFEBOAT RADIO	NAVIGATIONAL GEAR		FREQUENCIES	DATE IN FORCE	*GENERAL RADIO CONFERENCES*
			500 kc 2182 kc 8364 kc	1952	
Motor lifeboat CW manual or automatic keying. 25 mile range on 4000-27,500 kc. Portable gear unless 2 motor lifeboats equipped.	RDF	Radar recommended	500 kc 2182 kc 8364 kc	1965	1959 Geneva

*Exceptions

A1 CW
A2 Modulated CW
A3 Voice

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Contact at Sea: Footnotes

CHAPTER I

1. E. W. Pappenfus, "Single Sideband Techniques for Marine Communications," *Radio Technical Maritime Symposium Papers Delivered at the Fall Assembly Meeting* (Boston), *October 13-15, 1954*, (Mimeo) RTCM, Washington, D.C. (n d.), p. 50; Alvin P. Harlow, *Old Wires and New Waves* (New York, 1936), pp. 14-17. Harlow tells the interesting story of an early "marine telegraph" system (semaphore) set up in 1821 to pass messages from Staten Island to the Battery, with an extension in 1827 to Sandy Hook, and with a receiving station on the roof of the Merchants' Exchange on Wall Street. By this visual device information on incoming ships was passed to interested merchants and ship owners well in advance of the ship's docking time. The same source notes the refinement and improved efficiency (early nineteenth century) of the flag signals by Sir Home Popham in Britain and James M. Elford in the United States. As a result, flag signals developed a much larger vocabulary being widely used by both British and American merchant marine vessels. See Harlow, pp. 29-31

2. *Ibid.*, p. 11.

3. *Loc. cit.* Harlow is not strictly correct in assigning the invention of rockets to the seventeenth century. Actually they were used in Asia for military and festive purposes as early as the seventh century.

4 Two examples: the *Titanic* and the *Andrea Doria*

4a. An interesting case has recently been made for an American inventor, Mahlon Loomis claiming that he demonstrated a working wireless system over a fourteen-mile range in 1866. See Otis B. Young, "The Real Beginning of Radio: the Neglected Story of Mahlon Loomis," *Saturday Review* (March 7, 1964), pp. 48-50. There seems to be no evidence, however, that other inventors in the field of early wireless knew of his experiments.

5 Margaret Salzberg, "Homage to Hertz," *Proceedings of the IRE* (June, 1957), p. 2A

6 Orrin E. Dunlap, Jr., *Radio's 100 Men of Science: Biographical Narratives of Pathfinders in Electronics and Television* (New York, 1944), pp 96-97, 129-131. Less well known but also important in early ionospheric studies are the research and experimental work of Professor Gregory Breit of Yale, nuclear physicist and, like Marconi, a recipient of the Franklin Medal. See *Yale Alumni Magazine* (November, 1964), p. 21.

7 Dunlap, p. 77.

8. *Ibid.*, pp. 91-93

9 *Ibid.*, pp. 165-166.

10 James M. Herring and Gerald C. Gross, *Telecommunications, Economics and Regulation* (New York, 1936), p. 76.

11 E. M. Webster, "Global Marine Communications," *Proceedings of the Merchant Marine Council* (October, 1954), p. 159.

12 Herring and Gross, *loc. cit.*; Dunlap, pp. 173-174; Station WCC, a 35 kilowatt spark station, was built in 1901, but the destruction of its antenna system by storms delayed its going into operation until early 1903. See Appendix A. William Gould's compilation of the U.S. Navy and Canadian Government shore stations in 1908 indicates that of 13 Canadian stations, all used the Marconi system. Of the 43 U.S. Navy shore stations listed, none employed the Marconi system. 19 were Telefunken equipped, 3 were Fessenden, 5 were DeForest, with others making up the balance. See *The Old Timer's Bulletin, Official Journal, Antique Wireless Association*, 4 (Spring, 1963), p. 10. U.S. shore stations other than Navy listed in 1908 showed, out of a total of 59, DeForest 39; Marconi, 4 (one at South Wellfleet, another at Siasconset); Fessenden, 4; other 12. See *ibid.*, 3 (Fall, 1962), p. 12.

13 Harlow, pp. 443-444. Karl Baarslag, *SOS to the Rescue* (New York, 1935), pp. 3-4.

14 Harlow, p. 442; Baarslag, *loc. cit.*

15 "S'conset Sentinel of the Sea," *Ocean Wireless News*, VIII (no. 5), pp. 8-11, n.d; Harry E. Hancock, *Wireless at Sea, the First Fifty Years* (Chelmsford, England, 1950), pp. 50-51. Another contender for the distinction of "first" in sending out a distress call at sea is the S.S. *Kroonland*, which lost a propeller off the Irish coast on December 7, 1903. The operator was Ludwig Arnson. See the *New York Times*, December 9, 1956.

16 John D. Tomlinson, *The International Control of Radiocommunications* (Ann Arbor, 1945), pp. 12-13.

17 *Ibid.*, p. 11; Hancock, p. 77. An interesting sequel to Hancock's praise of "uniform control" occurred in 1926. He writes that in this year the Company secured control of Radio Communication Company, Ltd., its leading competitor, thus making possible economies in administration with no increase in charges to the shipping industry. He cited reductions that were made in some cases, as in rentals of direction finders, which 'was a very remarkable achievement . . . ." page 148.

18. Tomlinson, p. 12, Italy and Belgium, for example. In Germany there was more opposition to incorporation in Marconi's global empire, and the Arco, Braun, Slaby, Siemens, and Halske interests combined in 1903 to form the Telefunken Company as a competitive and not a subsidiary organization. *Ibid*., p. 13.

19 Herring and Gross, p. 79; Tomlinson, p. 12.

20 Hancock, p. 78.

21. Herring and Gross, p. 77.

22. *Ibid.*, pp. 77-78.

23. Tomlinson, *loc. cit.*; Harlow, p. 467. The same proviso appeared in Marconi's Italian contracts. See George A. Codding, *The International Telecommunication Union* (Leiden, 1952), p. 83.

24 Harlow, pp. 467-468.

25. *Ibid*, p. 468.

26 Carl Zollman, *Cases on Air Law* (St. Paul, 1932), pp. 294-295, n.3, n d This incident clearly fell in the period 1902-1903 before the first Berlin Conference in the latter year Incidents of this kind undoubtedly influenced Germany's pressing for international recognition of the necessity for obligatory intercommunication between different wireless systems. In this she was supported by the United States and others but not by Britain or Italy.

27. R. N. Vyvyan, *Wireless Over Thirty Years* (London, 1933), p. 51, n.d

CHAPTER II

1. Dimly sensed at the time but not fully understood was the fact that wireless signals over water were stronger than those over land Recent tests have shown that for a given power input the field intensity for ground wave propagation over water (e g , on 600 kc) is ten times that of propagation over land See Donald S Bond, *Radio Direction Finders* (New York, 1944), pp. 34-35. Many other factors are involved, such as "sky wave," but the fact remains that a coastal site provides a significant propagation advantage even for maritime shore stations with global capabilities. Station WCC at South Wellfleet on Cape Cod has long since been dismantled, but its successor, contemporary WCC (operated by RCA), is also located on the outer Cape, a short distance to the south at Chatham. An imposing complex of antennas, receiving and transmitting stations, WCC handles traffic (CW only) with ships sailing all the oceans of the world, For its Pacific coverage RCA operates a station at Bolinas, California, also a successor to an early Marconi installation. Through the latter station San Francisco and Honolulu were first linked by wireless on September 24, 1914. See *Wireless Age* II (October, 1914), pp. 21-23.

2 See Appendix A for further details The word "appropriate" in this paragraph means stations using the same system It has already been noted that Marconi operators, ship and shore, were forbidden to communicate with stations using other systems Attention should also be called to the fact that in the later days of wireless, ships with adequate sources of power were able to use Fessenden's rotary gap, which provided a signal vastly superior in readability to that of the fixed gap transmitter.

3 A revealing section on this subject may be found in Alvin P. Harlow, *Old Wires and New Waves* (New York, 1936), pp. 448-449.

4 Several of these basic problems have been effectively pinpointed in E M Webster, "Global Marine Communications," *Proceedings of the Merchant Marine Council* (October, 1954), p. 159.

5 France, Germany, Great Britain, Hungary, Italy, Spain, the United States, Russia, Austria.

6 James M Herring and Gerald C Gross *Telecommunications Economics and Regulation* (New York, 1936), p. 359

7 George A. Codding, Jr., *The International Telecommunication Union, An Experiment in International Cooperation* (Leiden, 1952), pp. 84-85.

8 *Ibid* p 85 See also John D Tomlinson, *The International Control of Radiocommunications* (Ann Arbor, 1945), pp 14 17 It should be noted that in the discussions on ship to shore traffic the British and Italian delegations proposed the addition of a 50% surcharge for the benefit of those shore stations that were operating more efficiently, i e., Marconi See Codding, pp 85-86, Tomlinson, pp 15-16 There was little support for this proposal, and it was not embodied in the Final Protocol.

9 Abstracted from Codding, p. 86.

10 *Ibid.*, pp. 86-87; Tomlinson, pp. 15-17.

11 Belligerent action was confined to East Asia, but France Germany, and Great Britain were either allied with the warring parties, or they viewed the conflict with concern in terms of their own world policies Even the United States, under the energetic leadership of President Theodore Roose velt was not inclined to stand completely aloof when great events were in the making As in World Wars I and II, an urgent radio conference was postponed because of the exigencies of the conflict. At the same time, the impact of power politics on radio conferences has been relatively light, due in part to the fact that major decisions tend to be more tech nical than political.

12. Tomlinson, pp. 17-18. He estimates that there were, in 1906, at least 400 coastal and 250 ship stations in operation. Figures arrived at for this period cannot be highly refined inasmuch as there was no central agency designated to compile and distribute this type of data. One of the results of the second Berlin Conference was the designation of the Berne Bureau of the International Telegraph Union as the administrative agency in respect to wireless matters

13. Codding, p. 88; Tomlinson, p. 19

14. Tomlinson, *loc. cit*

15 Codding, p. 89. Added point was given to the American proposal by citing the case of the *Lebanon* searching for a derelict endangering shipping in the Atlantic sea lanes Encountering the *Vaterland* the *Lebanon* questioned her by wireless, but the former Marconi equipped, refused to answer. See Tomlinson, p. 22. The chief non-signatories to the additional agreement were Great Britain, Italy and Japan. In regard to the latter, there is some uncertainty as to what system was in use. The most reasonable assumption is that the Japanese employed a pragmatic approach such as characterized by her borrowing from the West, and adopted what seemed to her the best in the few systems available Certainly the wireless of the Japanese Navy was fairly effective in the sea battles with the Russians as attested by the laments of the latter that Admiral Togo could direct and maneuver his ships by wireless whereas they did not have a similar capability.

16. Codding, p. 90.

17. Tomlinson, p. 20.

18. Codding, pp. 90-91, and n. 41.

19 The Berlin Conference produced two important documents that were to provide a general pattern for future radio conferences. One was the Con

vention, embodying the general principles to which the signatories subscribed, and describing the structure of the Union to be set up. The other comprised the Supplementary Regulations dealing with technical and regulatory matters, some of which will be described below Both the Convention and the Regulations were to take effect July 1, 1908. See Codding, p. 93.

20. *Ibid.*, p. 91.

21 *Ibid.*, p. 96. The signal SOS (...---...) has no meaning as a group of letters "Save our souls," etc , are phrases that had no place in the minds of those devising the call, which is merely an easily identifiable group of characters selected for this purpose A carry-over from land telegraph CQD had been used—CQ for the general call with D added for distress On February 1, 1904, the Marconi Company had chosen CQD as the urgent distress signal for use by its ship stations See Karl Baarslag, *SOS to the Rescue* (New York, 1935), pp 5-6. The Germans had argued for the call SOE but this was rejected in favor of SOS, which had a more decisive and easily identifiable final letter. The *Republic* used CQD, the *Titanic*, both CQD and SOS

22. Codding, p. 96.

23 Tomlinson, p. 26.

24 Codding, p. 95.

25. *Loc. cit.*

26 *Radio Laws of the United States* Public—No 262—61st Congress (1910), (Washington, 1962), p. 1.

26a. Early British regulation rested on this measure which gave to the Postmaster General authority to control wireless on British ships and in the United Kingdom With minor supplementary changes it was re enacted in 1906 for three years and was kept active on the books through inclusion in the Expiring Laws Continuance Bill The older legislation was not superseded until 1949, when the Wireless Telegraphy Act of that year restated the powers of the Postmaster General to police the ether in the interests of all users. See *Telecommunications Journal*, 17 (January, 1950), pp. 26-27.

27. Accounts of the *Titanic*'s sinking are many and varied For this summary the writer has drawn on the following Walter Lord, *A Night to Remember* (New York, 1955), *passim;* Hansen W. Baldwin, "R.M.S. Titanic," *Harper's Magazine* 168 (January, 1934) pp 170-179, John C Carrothers, "The Titanic Disaster," *United States Naval Institute Proceedings*, 88 (April, 1962), pp. 57-69 Captain Stanley Lord, Master of the *Californian*, had been held negligent in the deaths of 1503 of the *Titanic*'s passengers. In March, 1963 the British Merchant Marine Association exonerated him. See the *Hartford Courant*, March 16, 1963.

28 For example the sinking of the *Republic* in 1909 jarred Congress into enacting the Wireless Ship Act of 1910 In this case only two lives were lost, but the importance of wireless was dramatically highlighted Similarly, the tragedy of the *Titanic*'s sinking strongly influenced the London Conferences of 1912 and 1914, while the loss of the *Vestris* in 1928 gave added

ugency to the 1929 Conference on Safety of Life at Sea. In like manner the Safety Conference of 1960 met with the sinking of the *Andrea Doria* (1956) very much in mind.

29 For the rest of this study "radio" will replace "wireless". The literature on the subject has been plagued by terminological ambivalence. "Wireless," like the term "horseless carriage," was an uninspired designation wrenched from preceding practice and tended to linger on. It still survives in British usage. Since 1914 international practice has generally veered toward "radio," and to this trend the writer happily conforms.

30 Codding, p. 97.

31 *Loc. cit.* See note 12 above for earlier totals.

32 Codding, p. 97 and n. 79.

33 Tomlinson, p. 27.

34 *Ibid.*, p. 46.

35 Codding, pp. 100-101.

36 *Ibid.*, p. 100.

37 Quoted in Codding, p. 98. One near-by ship, working a land station at the time, did not hear the *Titanic*'s SOS. See also Tomlinson, p. 32.

38 *Ibid.*, p. 30.

39 It is more than coincidental that every international Radio Convention since 1912 has contained a clause on obligatory intercommunication. See, e.g., the most recent Convention, United States Department of State *Telecommunication Convention and Final Protocol Geneva, December 21, 1959* (TIAS 4892), (Washington, 1961), Art. 46, para. 282.

40. Codding, pp. 104-105.

41. E.g., by designating 500 kc as a calling frequency where stations having established contact move to another frequency for passing traffic. Silent periods are also specified and will be discussed later in this study. It is also interesting to note that experienced operators have an amazing ability to dredge up a faint signal from beneath a mass of heavy interference and to make "solid copy" where to the less experienced ear the signal is barely audible, much less readable. There is, of course, a limit to interference beyond which even the most skilled operator is able to produce copy.

42. Codding, p. 102.

43. *Ibid.*, pp. 102-108.

44. *Ibid.*, pp. 103-104; Tomlinson, p. 34.

45. *Ibid.*, p. 35.

46 Codding, p. 107.

47. Tomlinson, pp. 43-44.

48 Henry Reiff, *The United States and the Treaty Law of the Sea* (Minneapolis, 1959), pp. 104-105.

49. *Radio Laws of the United States*, Public -No. 238 - 62d Congress (1912), (Washington, 1962), p. 2

50 Reiff, p. 105. The Conference was in session from November 13, 1913, to January 20, 1914

51 Codding, pp 107-108.

CHAPTER III

1 *Radio Laws of the United States*, Public—No. 264—62d Congress (1912), "Regulations," (Washington, 1962), p. 5. Effective December 13, 1912, the law further stated that all radio stations within the jurisdiction of the United States must be licensed by the Secretary of Commerce and Labor, call letters must be assigned and published the designated wave length "shall not exceed six hundred meters or it shall exceed one thousand six hundred meters," ship stations must have a minimum range of 100 miles, intercommunication was obligatory regardless of the system used, distress calls were to have absolute priority, with penalties prescribed for false calls private and experimental stations (e g amateurs) were restricted to wave lengths under 200 meters and a power input not to exceed one kilowatt. Pp. 3-7.

2 Orin E Dunlap, *Radio's 100 Men of Science Biographical Narratives of Pathfinders in Electronics and Television* (New York, 1944), pp. 190-191.

3. See p. 4, this study.

4. For example the regenerative the tuned radio frequency the heterodyne the superheterodyne, with added refinements, would have been impossible without the audion and its successors Descriptions of these receivers and their development may be found in any good radio handbook.

5 Laurence Ashley Hawkins, "Research and Dr. Langmuir," *American Heritage* ("The Early Days of Radio an Unpublished Story From the Files of the Oral History Project" [Columbia University]) VI (August, 1955), pp. 70-71

6. James M. Herring and Gerald C. Gross, *Telecommunications. Economics and Regulation* (New York, 1936), p. 80.

7. *Ibid.*, p. 81.

8. *Ibid.*, pp. 81-82.

9 President Wilson was heavily engaged in his battle with the Senate over ratification of the Treaty of Versailles.

10. See Peter B. Schroeder, *The International Control of Amateur Radio Communications* [ms] (Worcester, Mass., Clark University, 1949), p. 8.

11. *Ibid.*, pp. 8-9.

12. Herring and Gross, p. 82.

13 John D. Tomlinson, *The International Control of Radiocommunications* (Ann Arbor, 1945), pp. 47-48.

14. *Ibid.*, p. 48.

15. *Ibid.*, p. 49

16. Important also is the fact that in the impassioned political atmosphere of 1920, German representation at an international radio conference would have been extremely doubtful. Certainly the Soviet Union would not have been invited, as it was not in 1927 (Washington). As a consequence she set up her own system of frequency allocations with results that should have been clearly predictible. Radio waves do not stop abruptly at international boundaries, as is amply demonstrated by contemporary history.

17 See n. 1 above.

18. For a fuller summary of these developments see Schroeder, *op. cit.*, pp. 10 13, Herring and Gross, pp. 90-94, Henry Reiff, *The United States and the Treaty Law of the Sea*, (Minneapolis, 1959), pp. 251-253; George A. Codding, Jr., *The International Telecommunication Union, An Experiment in International Cooperation* (Leiden, 1952), pp. 114-116, Schroeder, "The Radio Amateur in International Legislation and Administration," *AJIL*, 48 (July, 1954), pp. 421-433, and "The International Amateur Radio Union," *Telecommunication Journal*, 25 (January, 1958), pp. 3-8e.

19 See Schroeder, "The IARU," *op. cit* The number of national societies has increased since this article was written as has the total number of radio amateurs.

20. The importance of the morale factor is obvious here It means much to crew members at sea for long periods to be able occasionally to talk with their families via amateur radio phone patch. The same applies to service men stationed at overseas bases where amateur operations are likewise encouraged.

21. Codding, pp 116-117 Codding lists the countries and organizations attending the conference.

22. Land stations, not in the maritime service, operating on a point-to-point basis.

23. That amateurs were not excluded completely from the short waves they had been instrumental in opening up was due to the energetic support of their position by the American delegation, as a result of which the allocation table specified amateur frequencies at 160, 80, 40, and 20 meters

24. Sir Osborne Mance and J. E. Wheeler, *International Telecommunications* (London, 1944), p. 46.

25. Harry E Hancock, *Wireless at Sea, the First Fifty Years* (Chelmsford, England, 1950), p. 144.

26. Codding, p. 119.

27. *Ibid.*, p. 120

28. Tomlinson, p. 114.

29. *Loc. cit.* In the familiar low frequency bands, i.e. below 500 kc or above 600 meters. This terminological ambivalence was to prevail until the Atlantic City Conference of 1947, all allocation tables prior to that date indicating frequencies in both meters and kilocycles.

30. Tomlinson, p. 114.

31. *Ibid.*, p. 115.

32. *Ibid.*, p. 116.
33. *Ibid.*, p. 117.
34. *Loc. cit*
35. *Ibid.*, p. 118.
36. *Loc. cit.*
37. *Ibid.*, pp. 118-119.
38. *Ibid.*, p. 119 and n. 2.
39. *Ibid.*, p. 119.
40. Codding, pp. 167-168 Founded by French interests in 1928, with headquarters in Brussels, the International Radiomaritime Committee (IRMC) was also a persistent pro-spark group that defended the preservation of this mode of transmission up to the eve of World War II As an international non-governmental organization it could not participate directly in international radio conferences (e g , Madrid and Cairo) but was able to make its voice heard in varying degrees through the official delegations By 1938 IRMC was said to comprise fourteen maritime radio companies representing 60% of the merchant ships equipped with radio Two of the strongest members were the Marconi International Maritime Communication Company, Ltd , and the Radiomarine Corporation of America (RCA) See Lyman C White, *International Non-Governmental Organizations* (New Brunswick, N.J , 1951), p 59 The latter two companies worked out a system of jointly managed marine radio depots at strategic points on world trade routes where spare parts and expert servicing facilities were available Common agreements were also reached on charges to be made on services of this kind *Loc cit* It is interesting that Marconi receivers, regarded as the best available, were in use at some of RCA's Radiomarine stations in 1963.
41. Tomlinson, p. 120.
42. *Final Acts of the International Telecommunication and Radio Conferences Atlantic City 1947*, "Radio Regulations" (Atlantic City, 1947), p 136-E, Art. 33, para 1 and n 1. Hereafter cited as "Atlantic City Regulations."
43. *Ibid.*, p, 25-E.
44. *Ibid.*, p 27-E.
45. United States, Department of State, *Radio Regulations and Additional Protocol Geneva, 1959* (TIAS 4893) (Washington, 1962), p 142, Sec 677. Hereafter referred to as "TIAS 4893."
46. Atlantic City Regulations, p. 160-E, Art. 37, para. 4 (1).
47. *Ibid.*, para. 2.
48. *Ibid.*, p. 166-E, para. 3.
49 *Loc. cit.*
50. *Ibid* p 159-E, Art. 36, para 4 There is some ambiguity in this article, but the general purpose is fairly clear.

51. TIAS 4893, p. 233, Sec. 1382.

52. *Ibid.*, p. 142, Sec. 677.

53. *Ibid.* p. 20, para. 90.

CHAPTER IV

1. United States. United States Hydrographic Office, *Radio Navigational Aids 1953* (Washington, 1953), p. 396.

2. United States, Department of State. *Radio Regulations and Additional Protocol, Geneva, 1959* (TIAS 4893) (Washington, 1961), p. 102.

3. *Ibid.*, Chart, p. 414.

4. *Ibid.*, Allocation Table, pp. 38-102. See the frequency allocation references in this and the following paragraphs. For ready reference the table is arranged in ascending order of frequencies.

5. For the Madrid Allocation Table see James M. Herring and Gerald C. Gross, *Telecommunications, Economics and Regulation* (New York, 1936), pp. 365-371.

6. See, e.g., *Federal Register Title 47—Telecommunication, Federal Communications Commission*, Parts 7 and 8 (Washington, 1955), *passim*.

7. TIAS 4893, p. 150, para. 2; and p. 149, Art. 17.

8. As another consequence of the Cold War and increased interference, it should be noted that the U.S. armed forces maintain global radio networks with transmitters of great power. Designed to cut through interference, these likewise may create it on a formidable scale. See n. 58 below.

9. TIAS 4893, p. 21.

10. United States, Department of State, *Telecommunication Convention and Final Protocol Geneva, December 21, 1959* (TIAS 4892) (Washington, 1961), Art. 47, para. 285.

11. *Ibid.*, Art. 50, para. 290.

12. TIAS 4893, pp. 234-238.

13. A series of twelve dashes per minute, each dash being of four seconds duration, with a one-second interval between dashes, transmitted either automatically or by hand. See TIAS 4893, p. 242.

14. The Radio Regulations on this read: "The . . . alarm signal consists of two substantially sinusoidal audio frequency tones transmitted alternately. One tone shall have a frequency of 2200 cycles per second and the other a frequency of 1300 cycles per second, the duration of each tone being 250 milliseconds." See TIAS 4893, pp. 242-243. For additional provisions concerning radiotelephony in the maritime mobile service see *Ibid.*, Appendix 11, Sec. III-V; and Appendices 16-20.

15. *Ibid.*, p. 200, pp. 244-245.

16. *Ibid.*, p. 229. Applies to Regions 1 and 3.

17. *Ibid.*, Appendix 3, pp. 315-323.

18. The accuracy of WWV's standard frequency transmissions (on 2.5, 5, 10, 15, 20, and 25 mc) is better than one part in 100 million. See National Bureau of Standards, *Standard Frequencies and Time Signals from NBS Stations WWV and WWVH* (Washington, 1961), pp. 2-3. Station WWVB at Boulder, Colorado, also transmits a frequency standard on a limited basis, on 60 kc. WWV in addition transmits time signals, propagation forecasts (North Atlantic), standard audio frequencies, geophysical alerts. This same NBS bulletin lists other stations in various countries performing similar functions.
19. TIAS 4893, p. 168.
20. *Ibid.*, p. 180.
21. *Ibid.*, pp. 358-359.
22. *Ibid.*, p. 149.
23. *Ibid.*, p. 150.
24. *Ibid.*, p. 169.
25. William Gould (comp.), "List of Shore Stations in the United States (1908)," *The Old Timer's Bulletin Official Journal Antique Wireless Association*, 3 (Fall, 1962), p. 12.
26. William Gould (comp.), "List of Shore Stations Operated by the United States Navy (1908)," and "Shore Stations Controlled by the Canadian Government (1908)," *op. cit.*, 4 (Spring, 1963), p. 10.
27. United States, Bureau of Standards, (U.S. Army Signal Corps Radio Communication Pamphlet No. 40 Revised to May 24, 1921)], *The Principles Underlying Radio Communication*, Second Edition (Washington, 1922), p. 563. The Bureau did not, nor does the ITU, assign calls to individual stations. The international body designates blocks of letters from which each administration makes assignments to its own stations.
28. TIAS 4893, pp. 153-156.
29. *Ibid.*, p. 158.
30. *Ibid.*, pp. 157-161.
31. *Ibid.*, p. 361.
32. *Ibid.*, pp. 362-385.
33. Herring and Gross, p. 369.
34. Sir Osborne Mance and J. E. Wheeler, *International Telecommunications* (New York and London, 1944), pp. 46-47.
35. *Loc. cit.*
36. *Ibid.*, p. 47.
37. This ease of operation is often abused, as can be attested to by any one listening to the interchanges between fishing boats off Cape Henry for example. The sulphurous language, the utter irrelevancies, and the failure to use assigned call letters all add to the frustrations of the FCC monitoring service.
38. *Final Acts of the International Telecommunication and Radio Confer-*

ences: Atlantic City, 1947, "Radio Regulations" (Atlantic City, 1947), pp. 28-E to 33-E.

39. Long Range Aids to Navigation. This is a pulse, wide-band (50 kc) system of high accuracy, used by both ships and aircraft. It will be dealt with more fully in Chapter VIII.

40. U.S. Navy Hydrographic Office. "Loran Accuracy Diagram" (Washington 1954).

41. Atlantic City Radio Regulations, p. 29-E, n. 146 (32).

42. George A. Codding, Jr., *The International Telecommunication Union, An Experiment in International Cooperation* (Leiden, 1952), pp. 385-386, and n. 151. Other countries represented were Belgium, Denmark, Finland, France, Iceland, Ireland, Norway, Sweden, Portugal, Poland, and the USSR.

43. *Ibid.*, pp. 386-387. Stalin was being very difficult at this time, e.g., the Berlin Blockade was in mid-course.

44. *Ibid.*, p. 388.

45. TIAS 4893, p. 48, n. 195.

46. Region 1 is emphasized because it was there that the problem has been most acute.

47. TIAS 4893, pp. 107-108.

48. *Ibid.*, p. 393. The Geneva Regulations urge administrations to shift the radiotelephone transmissions of fixed stations in the bands below 30 mc from double to single sideband by January 1, 1970 if possible. See TIAS 4893, p. 112.

49. *Ibid.*, pp. 416-443, 444-445.

50. *New York Times*, October 13, 1957; American Telephone and Telegraph Company, Long Lines Department, *Overseas Telephone Service* (Pamphlet, n.d.).

51. TIAS 4893, pp. 142-143.

52. *Ibid.*, p. 142. The International Frequency Registration Board was created by the Atlantic City Radio Conference as an administrative agency of the ITU, its chief function being to "regulate the use of frequencies so that harmful interference could be eliminated . . . ." See Codding, p. 241 ff.

53. TIAS 4893, p. 144.

54. *Ibid.*, pp. 350-352.

55. United States, Federal Communications Commission: *28th Annual Report; Fiscal Year Ended June 30, 1962 (With Summary and Notation of Subsequent Important Developments)*, (Washington, 1962), p. 146. Hereafter referred to as *FCC Report, 1962*.

56. Codding, p. 354.

57. *FCC Report*, 1962, p. 163. It should be noted also that key Coast Guard stations in Washington (NMH) and San Francisco (NMC) perform monitoring functions, identifying the signal and measuring the frequency of any

station, domestic or foreign, that seems likely to interfere with Coast Guard operations. The results are forwarded to the Commandant for action. See *United States Coast Guard Communications Manual* (CG-233) (mimeo), 1961 (no place).

58. It is not known to the writer whether the relatively new super-power transmitters used by the armed forces have been the subject of interference complaints or not, although such may well have been the case For example, the "World Spanner"—so dubbed by the Army Signal Corps —with a capacity of 300 kw continuous or 600 kw peak power using SSB, ISB, CW, AM, Pulse, FSK, etc., is capable of operating anywhere in the high frequency spectrum from 4 to 30 mc The Navy and Air Corps have similar installations. The original Signal Corps station became operational in 1958, and some modifications have been made since that time 600 kw constitute enormous power, and designedly so, for such a station is placed in operation to punch readable signals through any type of interference, natural or man made, including jamming by countries that "do not wish us well." Similar super-power transmitters are in operation for the range 30-60 mc, the UHF bands, and the VLF (e g., NAA) frequencies as well Data on these transmitters furnished by courtesy of Continental Electronics. See also *Proceedings of the IRE* (June, 1957), pp 114A and 116A, and *Signal* (June, 1964), p. 59

Virtually any high frequency signal can be jammed if the country doing the jamming is willing to make the heavy investment necessary to do so, even though the technical difficulties involved can be very formidable. New military measures are usually followed by counter-measures if they are within the capabilities of the country devising them. Furthermore, with ionospheric propagation currently at its low-yield point, no amount of power will consistently produce a readable signal on the high frequencies at distant points since such a signal may be lost in space and not returned to earth. A highly relevant example—drawn from the Tonkin Gulf incident of early August, 1964—is the unsatisfactory character because of poor propagation conditions, of Pentagon communications with its Southeast Asian forces via direct high frequency circuits

Sheer power, in other words, is no guarantee of completely effective communications on the high frequency bands. Hence the plan to place in orbit enough satellites to provide virtually certain and jam-free communications with this country's distant military facilities, land, sea, or air Meanwhile it is hoped that use can be made of Syncom 3, which has apparently gone into successful equatorial orbit.

The relevance of these communications problems to the maritime community, particularly in time of emergency or war, is quite apparent.

CHAPTER V

1 For example, the LORAN C station on Nantucket initially caused interference on the 500 kc frequency until the spurious radiations were engineered out of the system.

2 William McFee, *The Law of the Sea* (New York, 1950), p 286, Karl Baarslag, *SOS to the Rescue* (New York, 1935), p. 153.

3. Baarslag, pp. 119-129, 133-139; McFee, p. 286.

4. Baarslag, pp. 16, 153; McFee, *loc. cit.*

5 International Convention for the Safety of Life at Sea, Ch IV, Art 26, para. 1; Art. 27, paras. 1 and 2; Ch. 1, Art. 2, para. 3(d). The provisions concerning communications in this convention are reprinted in full in James M Herring and Gerald C Gross, *Telecommunications, Economics and Regulation* (New York, 1936), Appendix C, pp 507 532. Hereafter referred to as SOLAS 29.

6. *Ibid.*, Art. 28.

7 *Ibid* Art 29 The continuous watch provision could be met by the designated categories of passenger and cargo ships through providing either an auto alarm (in addition to a qualified operator) or "certified watchers." These were required to be able to distinguish the "alarm, distress, safety, and urgency signals . . ." to copy 16 code groups per minute, and to regulate the ship's receivers. See SOLAS 29, Arts. 29 and 30.

8. *Ibid.*, Art. 31.

9 *Ibid.*, Arts. 34-35, 42-47.

10 *Ibid* , p. 507, n. 1.

11 Thomas Gallagher, *Fire at Sea The Story of the Morro Castle* (New York, 1959), *passim;* Baarslag, *passim.*

12. United States, Department of State, *Report of the United States Delegation Including Final Act and Related Documents, International Conference on Safety of Life at Sea London, April 23-June 10, 1948* (Washington, 1948), pp. 2-3. Hereafter referred to as SOLAS 48.

13 *Ibid.*, p. 58, Art. XV.

14 For the details of IMCO structure and functions see United States, Department of State, *Intergovernmental Maritime Consultative Organization* (TIAS 4044) (Washington, 1958). Short title: TIAS 4044.

15. *Ibid.*, Arts. 33-38, 23.

16. *Ibid.*, Arts 13-14.

17. *Ibid.*, Arts. 17-20.

18. *Ibid.*, Arts. 28, 31.

19. *Ibid* , Arts. 29-30. Sharp differences over Committee membership developed at the first session of the Assembly in 1959, and the matter was submitted to the International Court of Justice for an advisory opinion The Court ruled on June 8, 1960, that the Committee was improperly constituted On April 13, 1961, a new group was elected by the Assembly See *United Nations Yearbook 1961* (New York, 1962), p. 669. Actually the second election did not turn up a "new" group, for the membership of the major shipping powers remained the same, and was determined by the Convention. It was over the membership on the Committee of smaller powers that the dispute had arisen For sample press comments on this debate see the *New York Herald Tribune* 1959, Jan. 16, 17, 20, and the *New York Times*, Feb. 15, 1959.

20. TIAS 4044, Art. 3.

21. *New York Times*, Mar. 2, 1964.

22. See SOLAS 48.

23. *Ibid*, See Appen. 2, Ch. IV for examples.

24. Required was the accession of 21 states of which 7 should have shipping of not less than one million tons gross See TIAS 4044, Art. 60. SOLAS 48, on the other hand, specified 15 acceptances, 7 of which . . . . See SOLAS 48, pp. 56-57. The latter became effective in 1952.

25. SOLAS 48 Convention, Art. IX. See also Arts. III and VIII

26 Partially illustrative is the fairly recent case of the Mexican passenger vessel *Acapulco* Mexico had not ratified the SOLAS 48 Convention, and the United States Coast Guard, applying the higher American standards, refused to clear the ship for passenger service. The Mexican legislature hastily ratified the Convention, but inasmuch as three months must elapse before such accession becomes effective, the move was a vain one The *Acapulco* sailed from New York without her cruise passengers

27 With Liberia's acceptance on May 26, 1964, the requisite number of ratifications had been secured to place in force (on May 26, 1965) the 1960 Safety of Life at Sea Treaty. See the *New York Times* June 26, 1964 Fifteen acceptances are required to place the treaty in effect. See Senate, *International Convention for Safety of Life at Sea* (1960), 87 Cong., 1 Sess., Senate Executive 21248 K, Message from the President of the United States transmitting *International Convention for Safety of Life at Sea*, April 27, 1961 (Short title SOLAS 60) Convention, Art XI The translation published in Paris similarly states that the treaty is to go into effect after the deposit of fifteen acceptances *(quinze)*, of which seven etc See J Marie and M Bureau, *La Sécurité Maritime en 1960* (Paris, 1961), p. 7 The treaty has not been published in the United States, the reasons for which are not entirely clear When printed for the Senate it was classified as secret, the injunction of secrecy being removed April 27, 1961 It is available, however, in Readex Microprint, November, 1962, #21248 Presumably this type of reproduction became possible by virtue of the United States acceptance on August 2, 1962 One further point is necessary to note in connection with the effective date of the treaty—May 26 1965 The various exceptions noted are effective from the date the treaty goes into effect—not from the date of its completion. Thus the radiotelephone distress device, e g , would not be required until May 26, 1968.

28 Annex A to the Convention, "Regulations," has eight chapters General Provisions, Construction, Lifesaving Appliances, Radio, Safety of Navigation, Carriage of Grain, Carriage of Dangerous Cargoes, and Nuclear Ships Annex B deals with Regulations for Preventing Collision at Sea, C, with Recommendations for Nuclear Ships, D, with Recommendations (general).

29 Citations are to SOLAS 60, ' Regulations " Ch IV, unless otherwise indicated.

30 See this study, Appendix D, where the more significant exemptions are starred.

31 Spark, it will be recalled, is still legal for emergency transmitters, but is

carried by a relatively small number of vessels. It is to be dispensed with completely after January 1, 1966. See p. 20, this study.

32. SOLAS 60 Annex D This section consists of recommendations only which are not mandatory.

33. SOLAS 60, Annex A, Ch. III, Reg. 13.

34. See p. 38, this study. This provision carries a delay clause of three years.

35. *New York Times*, April 19, 1964

36. *Proceedings of the Merchant Marine Council* (March, 1962), p. 43. Short Title: PROMERMAC

37. *Loc. cit.* The existing convention in this case is SOLAS 60. See Annex A, Ch. V, Reg. 6 under which the United States agreed to continue the management of the Patrol.

38. *Air Sea Rescue Bulletin* (April, 1946), p. 35.

39. PROMERMAC (March, 1962), p. 44, and *Ibid.* (March, 1960), p. 47. Canadian sources also contribute to the general fund of information on which the periodic ice broadcasts are based See *Ibid* (March, 1963), p 44

40 "1958 International Ice Patrol" PROMERMAC (March, 1958), pp 44 45

41. *Ibid.* (March, 1962), p. 43.

42. *Ibid.* (March, 1963), p 45.

Chapter VI

1. See pp. 37-38, this study

2 United States Coast Guard (With Departments of the Army, the Navy, the Air Force the Treasury, and the Air Coordinating Committee), *National Search and Rescue Manual* (CG-308) (Washington, 1959), Ch. 5, p. 9. Short Title: CG-308.

3. United States, Department of State, *Report of the United States Delegation Including Final Act and Related Documents, International Conference on Safety of Life at Sea, London, April 23-June 10, 1948*, (Washington, 1948), Ch. V, Regulation 10. Short Title: SOLAS 48.

4. See this study, chapter VII, Sec. 1.

5. The efficiency of 500 kc as the world-wide distress frequency is controversial, but it is so firmly embedded in international regulations that a change would be most difficult By and large it has served its purpose well, and a shift to either a higher or a lower frequency would raise additional problems quite apart from those of allocations readjustment The survival of this frequency for distress is interesting in view of the fact that the type of equipment for which it was originally designated has largely ended up on the scrap pile or in museums The Soviet Union uses 4220 as well as 500 kc for distress off its Siberian Coast See U S Navy Hydrographic Office *Radio Navigational Aids* (HO 205) (Washington, 1962), Ch 5, p 8 HO 205 is now HO 117A.

6. HO 117A, Ch 5, p 6 A short treatment of an automatic radiotelephone

alarm will be recalled from the discussion of SOLAS 60 in the preceding chapter. This two-tone alarm, alternating four times per second, was prescribed in the 1960 treaty, with a three-year delay clause for its general use after the ratification of the treaty. The development of this device is still being pursued by the U. S. Coast Guard, which started its use experimentally in late 1961. It is anticipated that this two-tone signal will be able to cut through interference and thereby alert listeners to the fact that a distress call is on the air. See *Proceedings of the Merchant Marine Council* (February, 1962), p. 37. Short Title: PROMERMAC.

7. Senate, *International Convention for Safety of Life at Sea*, (1960), 87 Cong., 1 Sess. Senate executive 21249 K, Message from the President of the United States transmitting *International Convention for Safety of Life at Sea*, April 27, 1961 (Not published). Recommendation 42. Short Title: SOLAS 60.

8. CG-308.

9. *Ibid.*, Chart p. xiii. The Japanese Maritime Safety Board does, however, cooperate in SAR Plan ALFA described at close of this chapter.

10. Ibid., Ch. 5, pp. 3-4.

11. *Ibid.*, Ch. 5, pp. 5-6.

12. *Ibid.*, Ch. 5, pp. 6-7.

13. *Ibid.* Ch. 5, p. 7.

14. United States Coast Guard (With the Department of the Navy and the Department of the Air Force), *Aircraft Emergency Procedures Over Water* (CG 306) (Washington, Amended 1962), Ch. II, p. 2. Short Title: CG-306.

15. CG-308, Ch. 5, p. 8.

16. *Loc. cit.* The radio frequencies most commonly used in SAR, many of which have been repeatedly referred to in this study, are the following:

    500 kc, CW, world-wide for the mobile services
    2182 kc, voice, world-wide for the mobile services
    2670 kc, voice, Coast Guard Common
    3023.5 kc, voice, international, scene of SAR
    5680 kc, voice, international, scene of SAR
    8364 kc, CW, international, survival craft
    121.5 mc, voice, VHF international aero emergency
    121.6 mc, voice, VHF scene of SAR national
    138.78 mc, voice, joint SAR, working
    156.8 mc, voice, international calling and safety
    243 mc, voice, UHF military emergency
    282.8 mc, voice, UHF joint SAR working

    See CG-308, Ch. 5, p. 9. 'Crystallization'—the use of crystals for accurate frequency control in both transmitters and receivers aboard OSV's—is now in effect to achieve greater uniformity in communications capability. See United States Coast Guard Eastern Area, *Standard Operating Procedures for Atlantic Ocean Stations* (Annex Golf to COMEASTAREA OpPLAN, [FY]) (New York, 1964) Ch. 6, pp. 30-33. Short Title: SOP LANTOS.

17. United Nations, *Everyman's United Nations* (New York, 1950), p. 252.

18. Captain Jacob Schenkman, *International Civil Aviation Organization* (Geneva, 1955), pp. 280-281.

19. *Ibid.*, p. 111.

20. *Everyman's United Nations*, p. 253. These were to be manned by twenty-five ships. Each OSV averages thirty three days per patrol: twenty-one days on station, with twelve en route and return. Even in port an OSV is on standby duty for SAR. See SOP-LANTOS Ch. 1, p. 1.

21. *Ibid.*, Ch. 6, p. 2.

22. *Ibid.*, Ch. 6, p. 3. The OSV's also carry radioteletype for ship to shore communications. *Ibid.*, Ch. 6, p. 24.

23. *Ibid.*, Ch. 4, pp. 2-2A.

24. *Ibid.*, Ch. 6, pp. 5-6.

25. *Ibid.*, Ch. 5, p. 1.

26. It is asserted that LORAN C provides a ground wave fix accurate within 1500 feet. See HO 117A (May, 1963), Ch. 7, p. 4b. OSV's also carry radar for surface and air search.

27. The familiar bands and calling frequencies designated for the maritime mobile service range from 4 to 22 mc.

28. Such as alerting appropriate maritime and aero shore stations. See SOP-LANTOS, Ch. 6, p. 11.

29. *Ibid.*, Ch. 6, pp. 12-13 and n. 16 above. For example, the high frequency on which 4YB would normally contact NMH directly might become unusuable, necessitating lower frequency relays by other OSV's and shore stations. In the case of a sudden ionospheric disturbance (SID) which can not be forecast, the frequencies between 4 and 15 mc may be knocked out for periods ranging from a few minutes to several hours. In the case of a magnetic storm, however, with the higher latitudes most severely affected, the disturbed condition may last for several days. Again the employment of relays on the lower frequencies become necessary. See *ibid.*, Ch. 6, pp. 15-17.

30. Schenkman, p. 280; e.g., the CG cutter *Duane*, on weather patrol, saved twenty-eight crewmen of the sinking Finnish freighter *Bornholm*.

31. CG-308, Ch. 5, p. 6.

32. The press for the week of October 17, 1956, carries full accounts of the incident. See, e.g., the *New York Herald Tribune*, October 17, 1956. For a graphic and pictorial account see *Life* (October 29, 1956), pp. 23-30. The naval vessels diverted to the scene were recalled when it became evident that their services were not needed. Flying Tiger 923 on the night of September 23, 1962, was less fortunate, for the nearest weather ship was ten hours distant. En route from Gander to Frankfurt with seventy six persons aboard, the Constellation successively lost three of its engines. With the second failure the pilot changed course to Shannon, but with the third he was forced to ditch by his landing lights alone with winds up to thirty five knots and in waves fifteen feet high. Alerted by the plane's distress

call SAR was immediately activated and search planes were soon over the area Spotted by AMVER, the *Celerina* was directed to the scene and picked up forty eight survivors from a raft designed for twenty five Twenty-eight persons were lost See press reports for this period and Senior Master Sergeant Peter A. Foley, 'We ditched at Sea the Ordeal of Flying Tiger 923," *Saturday Evening Post* (November 17, 1962), pp. 97-101.

33. PROMERMAC (April, 1959), p. 75.

34 SOP-LANTOS, Ch. 1, p. 2. The importance of the science of oceanography was made apparent by the search for the *Thresher*. In the course of this action, as Captain Andrews notes, the character of the search quickly changed "from that of a standard Navy search and rescue operation to that of an oceanographic expedition." See Captain Frank A. Andrews, USN, "Searching for the Thresher," *United States Naval Institute Proceedings* (May, 1964), pp. 69-77; and E. W. Grenfell, "USS *Thresher* (SSN-593)," *ibid.* (March, 1964), pp. 36-47.

35 SOP-LANTOS, Ch. 3, p. 8

36 *Ibid* , Ch. 1, p. 3.

CHAPTER VII

1 Frequent accounts of AMVER and its operations appear in the pages of the *Proceedings of the Merchant Marine Council* (Short Title: PROMERMAC) to which the reader is referred Particularly recommended is the article by Paul Van Wicklen, 'They Plot for Safety's Sake," PROMERMAC (June, 1963), pp. 100-101. Specific instructions to the Coast Guard OSV's may be found in United States Coast Guard, Eastern Area, *Standard Operating Procedures for Atlantic Ocean Stations* (New York, 1964) (Short Title: SOP-LANTOS), Ch 6, pp. 21-23. It was announced in December, 1964, that AMVER coverage had been extended to the South Atlantic, and that it would be applied to the North Pacific by mid-1965. See the *New York Times*, December 20 1964 Since this change, AMVER now means Automated Merchant Vessel Reports.

2 The *New York Times*, May 5, 1964.

3. *Loc. cit*

4 This includes such items as name of vessel call sign, position, sailing route speed, destination estimated time of arrival, radio schedule and frequencies, type of propulsion HF and VHF capability, radiotelephone surface search radar, doctor on board

5 U. S Navy Hydrographic Office, *Radio Navigational Aids* , Washington 1963), Ch. 5, p. 11.

6 PROMERMAC (November, 1961), pp 204-205 Another chance rescue, also directed toward a tanker that broke up before it could send a distress call, involved the *Amphialos* 393 miles east of Boston An RCAF plane on maneuvers with a small surface force spotted the stern section of the tanker wallowing in heavy seas, and radioed the Canadian destroyer-escort *Athabaskan* Of the thirty six man crew thirty-four were rescued, eighteen from the stern and sixteen from lifeboats See the *New York Times*, March 2, 3, 1964.

7. *Newsweek*, January 6, 1964, p. 30

8. The *New York Times*, February 19, 1964.

9. PROMERMAC (September, 1960), p. 161.

10 Recommendation 41 of SOLAS 60 urged that a working group made up of representatives from IMCO, ICAO, ITU and WMO give urgent consideration to the problem of ship-aircraft communications

11 PROMERMAC (August, 1956), p. 135.

12. *Ibid.*, (March, 1962), interleaf, pp. 48-49

13. This study, Ch. VI, p. 66.

14. Art. 44, Sec. III, Paras. 9-10. The CW urgency signal is XXX thrice repeated For radiotelephone it is PAN also repeated three times The urgency signal takes precedence over all others except the distress call.

15 The *New York Times*, August 27, 1963.

16. See "International Code of Signals," HO 88, vol. II. For the list of countries participating in this service see U S Navy Hydrographic Office, *Radio Navigational Aids* (HO 117A) (Washington, 1962, with subsequent changes) This publication formerly was HO 205 In 1967 the Navy Hydrographic Office became the Navy Oceanographic Office.

17. HO 117A, Ch. 6, pp. 1, 4

18 SOP-LANTOS, Ch. 7, p. 2.

19. PROMERMAC (August, 1955), p. 131.

20. *Ibid* , pp. 132, 143

21. *Ibid.*, (February, 1962), p. 36

22. *Ibid.*, (March, 1960), p. 43. In 1953, the latest year for which totals have come to the attention of the writer, 2011 MEDICOS were handled by U S radio stations and USPHS. See n. 19 above.

23. Two sources were primarily used in this section. One, *The Story of the Life-Boat 1963*, apparently is an occasional journal published in Edinburgh, this issue commemorating the 9th International Life Boat Conference in June, 1963. The second, by Julia G. Fox, *The Maritime Safety Board of Japan: a Brief Study* (ms), Tokyo, Sophia University, 1959, is a very useful compression of the functions and organization of the Japanese Maritime Safety Board—the counterpart of the U S Coast Guard Both were made available to the writer through the courtesy of Mr. Robert Dixon, Jr., Assistant Librarian, U. S. Coast Guard Academy, New London, Connecticut

24. The *New York Times*, August 31, 1963.

25. The *New York Herald Tribune*, January 16, 1957.

26. The *Hartford Courant*, February 17, 1963; The *New York Times*, April 19, 1964. This same *New York Times* account makes reference to a SOLAS 60 provision that ships (category unspecified) carry an emergency distress and beacon transmitter—a unit that would float if the ship went down. Presumably this would be patterned after the survival craft equip

ment long in use, but would automatically transmit its signal once it was water-borne. This would pinpoint the search for survivors as well as indicating that a ship had gone down

27. See p. 68, this study

28. See fn. 6 above.

CHAPTER VIII

1. Quoted in Alan Villiers, "Ships Through the Ages: a Saga of the Sea," *National Geographic* (April, 1963), p. 512.

2. In September, 1923, seven ships of Destroyer Squadron 11 were lost on the rocks of Honda. A contributory factor in the disaster was the reliance placed on dead reckoning calculations which seemed to place the squadron well out to sea and south of Point Conception when actually the *Delphy* (flagship of the squadron) was farther north close inshore off Honda Point When the *Delphy* signaled the left turn that was to take her and the squadron down the Santa Barbara Channel, she led the way directly into the Devil's Jaw See Charles Lockwood and Hans Christian Adamson *Tragedy at Honda* (New York, 1960), *passim*.

3. *Bureau of Ships Journal* (March 1959), p. 2.

4. "SCAR Navigation System Demonstrated by Navy for Use in Guiding Submerged Submarines," *Bureau of Ships Journal* (July, 1959), p. 36.

5. *United States Naval Institute Proceedings* (January, 1964), p. 11. Short Title: NAVINSTPROC.

6. *Proceedings of the Merchant Marine Council* (February, 1957), pp. 27-28. Short Title: PROMERMAC.

7. Over 22,000 See the *New York Times*, June 23, 1963

8. LTJG Thomas F Budinger USCGR, Ice Detection by Radar," PROMERMAC (September, 1960), pp. 152-154.

9. LCDR R. T. Norris, USCG, "Electronic Aids to Navigation," PROMERMAC (January, 1959), p. 3; *Ibid*, (June, 1963), p. 96.

10. "Revised Radio Beacon System," PROMERMAC (June, 1963), pp. 96-98; Norris, pp. 4-5; U. S. Navy Hydrographic Office, *Radio Navigational Aids* (HO 117A) (Washington, 1963) lists maritime and aeronautical radio beacon stations for different areas, giving name of facility, frequency in kc, characteristic signal, call sign, exact location in terms of latitude and longitude, and type of emission. Short title for this reference: HO 117A Also of interest at this point is the empirical shift in United States policy with respect to the shore-based radio beacon. Ten years ago policy centered on a three fold approach LORAN for long range position fixing (over 50 miles), shipboard MF DF with radio beacons having a range of 3-50 miles and shipboard radar for short-range position fixing (under 3 miles). See Radio Technical Commission for Marine Services (RTCM), *Review of Existing United States Policy with Respect to Medium Distance Navigational Aids* (Washington, 1952), p. 2.

11. For example, the station on Nantucket is paired with stations on Hatteras Sandy Hook, and Nova Scotia.

12. Norris, p. 5, HO 117A, Ch. 7, p. 1. There are sixty LORAN A stations in operation, eleven by countries other than the United States. All stations under the jurisdiction of the United States are operated by the Coast Guard.
13. HO 117A, Ch. 7, p. 4b.
14. *Ibid.*, p. 4a.
15. Norris, p. 21.
16. HO 117A, Ch. 7, p. 4c.
17. Norris, p. 5, HO 117A, Ch. 7, p. 5. One CONSOL station is operating in the United States—at Miami, on 190 kc. Its call sign is MMF.
18. HO 117A, Ch. 7, pp. 29-30. The frequency is 194 kc.
19. Norris, p. 5.
20. *Loc. cit*; Alice S. Fuchs, "DECCA," *Flying* (March, 1955), pp. 26-27.
21. Fuchs, p. 27; *U. S. News and World Report* (March 7, 1958), p. 11.
22. Captain Frank A. Andrews, USN, "Searching for the Thresher," NAVINSTPROC (May, 1964), pp. 73-74.
23. Norris, p. 21.
24. PROMERMAC (July, 1962), pp. 107-109.
25. The *New York Times*, September 29, 1963.
26. ADM E. J. Roland, USCG, "A View and a Review of Maritime Safety," PROMERMAC (February, 1963), p. 24.
27. *Loc. cit.*
28. The *New York Times*, September 29, 1963.
29. *Ibid.*, February 23, 1964.
30. *Newsweek* (August, 31, 1964), p. 10.

CHAPTER IX

1. *Proceedings of the Merchant Marine Council* (February, 1957), p. 25. Short Title PROMERMAC, U. S. Navy Hydrographic Office (HO 205), *Radio Navigational Aids* (Amended), (Washington, 1955), Ch. 4, pp. 1, 4-5, 22-72.
2. *Ibid.*, Ch. 4, p. 5.
3. *Ibid.*, Ch. 5, p. 6.
4. *Ibid.*, Ch. 4, pp. 1-3.
5. PROMERMAC (February, 1957), p. 25.
6. *Loc. cit.*
7. HO 205, Appendix B.
8. U. S. Navy Hydrographic Office, *Radio Weather Aids* (HO 118; formerly HO 206) (Washington, 1961), Sec. 2, "Marine Broadcasts," Index 1-4.
9. *Ibid.*, Part 1, Ch. 2, pp. 1-92.
10. *Ibid.*, Ch. 1, pp. 17-21. The total of this list is about 150 stations.

11. *Ibid*., pp. 17-19.
12. This study, Ch. IV and n. 18; Ch. VIII, p. 77.
13. See HO 117A (formerly HO 205) Ch's 3 and 9 for a comprehensive list of such stations
14. National Bureau of Standards, *Standard Frequencies and Time Signals from NBS Stations WWV and WWVH* (Washington, 1961), p. 7. Short Title: NBS.
15. *Ibid.*, p. 2. See also Ch. IV, n. 18, this study. Time signals are broadcast at scheduled hours but not continuously by U S Navy radio stations NSS (Washington), NBA Balboa), NPG (San Francisco), and NPM (Honolulu). See HO 205, Appendix B
16. See NBS p. 3 for a technical discussion of standard time intervals.
17. This study Ch. IV, n. 18
18. NBS p. 4.
19. *Loc. cit.*
20. *Ibid.*, p. 5.
21. See n. 17 above
22. This study, Ch. V, p. 56.
23. HO 117A, Chg 2 (May, 1963), Ch 10 pp 2, 3 United States Coast Guard Eastern Area, *Standard Operating Procedures for Atlantic Ocean Stations* (New York, 1957, amended to 1964), Ch. 6, p. 20.
24. HO 117A, Ch. 10, pp. 10-11, and Chart. MERCAST schedules are included in the broadcast program of many naval radio stations, thus maintaining alertness in the event of hostilities
25. *Ibid.*, Ch. 11, pp. 1-5.
26. This station went into operation June 23, 1961, using the famous call of NAA.
27. Not yet operational at time of writing.

CHAPTER X

1. Quoted in George A. Codding, *The International Telecommunication Union, An Experiment in International Cooperation* (Leiden, 1952), p. 109
2. General Secretariat of the International Telecommunication Union, *List of Coast and Ship Stations, Vol. I—Coast Stations* (32nd Edition—March, 1959), Geneva, ITU, 1959
3. General Secretariat of the International Telecommunication Union, *List of Ship Stations* (3rd Edition—December, 1962), Geneva, ITU, 1963. Short Title: ITU *List of Ship Stations*.
4. This study, Ch. IV, pp. 36-37.
5. Atlantic City, 1959.

6 Also under the "fixed" services are the commercial point-to-point circuits which do not, however, constitute a threat to the maritime frequencies As conspicuous losers at a succession of radio administrative conferences, they will be fighting a rear-guard action to avert further cuts rather than attempting to expand their present holdings. The date of the next administrative conference had not been determined at the time of writing

7 Ch. VI, pp. 58 59.

8 Details provided in the ITU *List of Ship Stations*. Similar data are given for all ship stations listed

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